



Figure 3-23. Subsidence in the Subsurface Disposal Area.



Figure 3-24. Subsidence in the Subsurface Disposal Area.

Historically, subsidence areas have been repaired by filling holes with soil from spreading areas. Soil is hauled to the area, dumped close to the subsidence, and pushed into the hole with a front-end loader. The soil is compacted by hand or by driving a front-end loader over the filled area. During spring thaw, vehicles are prohibited from driving over waste disposal areas in the SDA. As of spring of 2005, sizable subsidence areas were filled with grout, while smaller areas were filled with soil.

3.2 Summary of Waste Area Group 7 Operable Units

As previously mentioned, Waste Area Group 7 was subdivided for assessment using criteria that differed from those applied to other waste area groups at the INL Site. For example, some operable units in Waste Area Group 7 are defined in terms of exposure pathways rather than the physical delineation of units. Site codes also were assigned differently than for other waste area groups. Other waste area groups were divided into operable units that were further subdivided into sites. Each site was assigned a unique site code. Sites within a given operable unit having similar physical characteristics or operational histories were grouped into operable units to expedite investigation. Operable Unit 7-11 was the only operable unit of the 14 operable units assigned to Waste Area Group 7 that was subdivided into sites. The three sites in Operable Unit 7-11 are identified as RWMC-01, -02, and -03. The six operable units comprising the SDA (i.e., Operable Units 7-01, 7-02, 7-03, 7-10, 7-12, and 7-13) were given the same site code (i.e., RWMC-04). Despite the shared site code, different operable units are addressed with varying levels of investigative rigor (i.e., Track 1 and Track 2 investigations, interim actions, and RI/FS). The only other waste area group site code (i.e., RWMC-05) was assigned to the Track 1 investigation of historical releases in the TSA, also known as Operable Unit 7-09. Operable Unit 7-14, the comprehensive RI/FS, was combined with Operable Unit 7-13, the RI/FS for pits and trenches. This combined operable unit is now Operable Unit 7-13/14 (see Section 1.4). Three other site codes address specific exposure pathways, and two operable units address the vadose zone beneath RWMC.

Three of the 14 operable units of Waste Area Group 7 were designated for Track 1 investigation, six were designated for Track 2 investigation, one was designated for interim action, and four were designated for an RI/FS. Most operable units were evaluated to some extent before starting work on the Operable Unit 7-13/14 comprehensive RI/FS. Many of the investigations were initiated under the Consent Order and Compliance Agreement (DOE-ID 1987). Therefore, Track 1 and 2 investigations were in progress when the FFA/CO (DOE-ID 1991) was signed, and most were completed before the DOE guidance documents (DOE-ID 1992, 1994b) for such evaluations were complete. All but Operable Unit 7-11, septic tanks and drain fields, were rolled into the Operable Unit 7-13/14 comprehensive RI/FS. The operable unit sites, classifications, and brief descriptions are given in Table 3-20. The descriptions include brief summaries of the completed CERCLA investigations. Additional information about each Waste Area Group 7 operable unit is presented in subsequent subsections.

3.2.1 Operable Unit 7-01, Subsurface Disposal Area Soil Vaults, Track 2 Investigation

In the Operable Unit 7-13/14 RI/FS Work Plan (Becker et al. 1996), 21 SVRs were identified within the SDA. However, the Operable Unit 7-01 Track 2 investigation (Burns, Becker, and Jones 1994) addressed only those disposals occurring from 1977 to 1983 and buried in SVRs 1 through 13. Waste buried in SVRs 14 through 21 (1984 to 1995) meets current RWMC waste acceptance criteria and is not included in the definition of Operable Unit 7-01. Total inventory from all SVRs is evaluated in the Ancillary Basis for Risk Analysis (ABRA) (Holdren et al. 2002). Except as noted otherwise, the following information was taken from the Track 2 Summary Report (Burns, Becker, and Jones 1994), which indicated that all soil vaults would be reanalyzed in the Operable Unit 7-13/14 comprehensive RI/FS.

Table 3-20. Operable units and sites in Waste Area Group 7.

Operable Unit	Description and Summary	Classification
7-01	SDA soil vaults. The Track 2 investigation (Burns, Becker, and Jones 1994) evaluated only SVRs 1 through 13. Assessment of SVRs 14 through 20 was deferred to the comprehensive RI/FS (Operable Unit 7-14). The investigation, based on existing data, identified potential unacceptable risk. Because existing data were not sufficient to make remedial decisions, Operable Unit 7-01 was slated for combination with the Operable Unit 7-13 or Operable Unit 7-14 RI/FS.	Track 2
7-02	SDA Acid Pit. A result of the Track 2 investigation (Jorgensen et al. 1994) was identifying potential unacceptable risk from mercury in the groundwater ingestion pathway. The decision to roll Operable Unit 7-02 into the TRU waste pits and trenches RI/FS (Operable Unit 7-13) was based on large uncertainties in several sensitive parameters used in the Track 2 risk assessment. In 1997, the Acid Pit was grouted as part of a treatability study (Loomis, Zdinak, and Jessmore 1998). The Acid Pit was evaluated further in the Interim Risk Assessment (Becker et al. 1998), based on additional studies to reduce uncertainties, and the site was subsequently eliminated from further evaluation (DOE-ID 1998b).	Track 2
7-03	Non-TRU-contaminated waste pits and trenches. The Track 1 investigation (INEL 1993a) evaluated existing data for three of 18 pits, 26 of 58 trenches, and no SVRs. Potential unacceptable risk was identified for multiple radioactive and nonradioactive constituents. Therefore, Operable Unit 7-03 was rolled into the TRU pits and trenches RI/FS (Operable Unit 7-13).	Track 1
7-04	Air pathway. The Track 2 preliminary scoping screening (INEL 1994a) evaluated air pathway exposures for the entire SDA (i.e., pits, trenches, and soil vaults). Potential unacceptable risk was identified for Am-241 and carbon tetrachloride. Operable Unit 7-04 was retained for further evaluation using more refined techniques in the pits and trenches RI/FS (Operable Unit 7-13) and the comprehensive RI/FS (Operable Unit 7-14).	Track 2
7-05	Surface water pathways and surficial sediment. Potential unacceptable risk by Cs-137 external exposure was identified for both occupational and residential scenarios (Burns, Loehr, and Waters 1993). The Action Determination (DOE-ID 1994c) preserved Operable Unit 7-05 for the pits and trenches RI/FS (Operable Unit 7-13) and the comprehensive RI/FS (Operable Unit 7-14) to ensure further evaluation for surface water pathways and surficial sediment associated with the SDA.	Track 2
7-06	Groundwater pathway. Previously acquired information and data collected under the Track 2 investigation (Burgess, Higgs, and Wood 1994) were used to evaluate groundwater contamination associated with RWMC operations. The Action Determination (DOE-ID 1994a) for Operable Unit 7-06 calls for continued monitoring of groundwater and further evaluation of risk in the pits and trenches RI/FS (Operable Unit 7-13) and the comprehensive RI/FS (Operable Unit 7-14).	Track 2
7-07	Vadose zone radionuclides and metals. The only exposure pathway associated with Operable Unit 7-07 is groundwater ingestion. Unacceptable risk for total nitrogen and several radionuclides was identified in the Track 2 investigation (INEL 1994b), which included a summary of the results of the Preliminary Scoping Risk Assessment (Loehr et al. 1994) and the Revised Preliminary Scoping Risk Assessment (Burns et al. 1994). Therefore, Operable Unit 7-07 was retained for more refined assessment in the pits and trenches RI/FS (Operable Unit 7-13) and the comprehensive RI/FS (Operable Unit 7-14).	Track 2
7-08	Vadose zone organics. The OCVZ RI/FS (Duncan, Sondrup, and Troutman 1993) identified unacceptable carcinogenic and noncarcinogenic risk. A remedial action to remove vapors using vapor vacuum extraction was implemented and is currently in progress. Data obtained from the OCVZ Project were incorporated into the comprehensive RI/FS (Operable Unit 7-14).	RI/FS

Table 3-20. (continued).

Operable Unit	Description and Summary	Classification
7-09	TSA releases. This Track 1 investigation (INEL 1993b) evaluated the risk potential from radionuclide, organic, and inorganic contamination resulting from historical TSA operations. Insufficient data were available to support a decision; therefore, the operable unit was deferred to the Operable Unit 7-14 comprehensive RI/FS for additional evaluation (DOE-ID 1998b). Subsequently, however, further assessment of Operable Unit 7-09 was delayed. To facilitate final decision-making and completion of Operable Unit 7-13/14, final evaluation of Operable Unit 7-09 is being postponed until TSA operations are complete and the facility is closed.	Track 1
7-10	Pit 9 process demonstration. A preliminary risk assessment (McClellan, del C. Figueroa, and King 1991) supported classification of Pit 9 as an interim action. The remedy selected and documented in the Pit 9 ROD (DOE-ID 1993) includes physical separation, treatment, and stabilization of Pit 9 waste. The Pit 9 ROD was modified in 1998 (DOE-ID 1998a) to a revised, three-staged approach for implementing the remedy. Stage I focused on subsurface characterization and was largely completed. Stage II, involving limited retrieval, eventually became the now-complete Operable Unit 7-10 Glovebox Excavator Method Project. Remaining work under Operable Unit 7-10 has been delayed while the Accelerated Retrieval Project in Pit 4 is being implemented.	Interim action
7-11	Septic tanks and drain fields. Operable Unit 7-11 comprises three septic systems within RWMC, two in the administrative area and one in the TSA. The Track 1 investigation found no unacceptable risk. A No Further Action Determination (INEL 1993c) was signed, and Operable Unit 7-11 was eliminated from further study in the comprehensive RI/FS (Operable Unit 7-14).	Track 1
7-12	Pad A. The Pad A RI/FS (Halford et al. 1993) identified potentially unacceptable future scenario risk caused by ingestion of nitrate-contaminated groundwater. The ROD (DOE-ID 1994e) documented the remedial action selected for Operable Unit 7-12, which consisted of augmenting and maintaining the existing soil cover, monitoring environmental media, and continuing institutional control indefinitely. The decision to include Operable Unit 7-12 in the comprehensive RI/FS (Operable Unit 7-14) was based on the revised Pad A inventory documented in the Historical Data Task (INEL 1995a) and the requirement to assess cumulative risk in the comprehensive RI/FS (Operable Unit 7-14).	RI/FS
7-13	TRU pits and trenches. The Preliminary Scoping Risk Assessment (Loehr et al. 1994) and the Revised Preliminary Scoping Risk Assessment (Burns et al. 1994), in conjunction with information from assessments of other operable units in Waste Area Group 7, revealed the implausibility of evaluating risk for the SDA solely based on the exposure pathway or segregated source terms. Therefore, Operable Unit 7-13 was combined with Operable Unit 7-14 (Huntley and Burns 1995) for the comprehensive RI/FS (Operable Unit 7-14).	RI/FS
7-13/14	Waste Area Group 7 comprehensive RI/FS. The Operable Unit 7-13 RI/FS was combined with Operable Unit 7-14 (Huntley and Burns 1995) to become Operable Unit 7-13/14. However, the RI/FS is being published in two primary documents DOE (2002): an RI/BRA and a feasibility study. Precursor risk assessments (Becker et al. 1998; Holdren et al. 2002) and an analysis of alternatives (Zitnik et al. 2002) are predecessor analyses. The comprehensive RI/BRA and feasibility study address cumulative risk associated with the SDA. With the exception of Operable Units 7-02, 7-09, and 7-11, all of the operable units listed above are considered in the evaluation.	RI/FS
<div>OCVZ = organic contamination in the vadose zone</div> <div>RI/FS = remedial investigation and feasibility study</div> <div>ROD = record of decision</div> <div>RWMC = Radioactive Waste Management Complex</div> <div>SDA = Subsurface Disposal Area</div> <div>SVR = soil vault row</div> <div>TRU = transuranic</div> <div>TSA = Transuranic Storage Area</div>		

As discussed in Section 3.1.2.4, soil vault disposal began in 1977 to conserve disposal space available within RWMC and to minimize personnel exposures to ionizing radiation (INEL 1985). Soil vaults were designed for disposal of high-radiation waste, which is defined as material producing a beta-gamma exposure rate of greater than 500 mR/hour at a distance of 0.9 m (3 ft). Soil vaults are unlined, vertical, cylindrical borings ranging from 0.4 to 2 m (1.3 to 6.5 ft) in diameter and averaging about 3.6 m (12 ft) deep. When basalt was penetrated during drilling of the soil vault, at least 0.6 m (2 ft) of soil was placed in the hole to cover the bedrock underlying the vault. Soil vaults are drilled in precise rows, with individual vaults separated from their neighboring vaults in the same or adjacent rows by a minimum of 0.6 m (2 ft). Soil vault rows are scattered throughout the southern two-thirds of the SDA.

The Track 2 evaluation of SVRs 1 through 13 (Burns, Becker, and Jones 1994) was based on existing inventory data, and new samples were not collected from the SVRs. A semiquantitative risk evaluation in the Track 2 investigation addressed a current occupational scenario and three residential exposure scenarios (i.e., 30, 100, and 1,000 years in the future). External exposure to ionizing radiation was the only exposure pathway of potential concern identified for the current occupational scenario. External exposure to ionizing radiation and ingestion of groundwater were considered for the three residential evaluations. All other exposure scenarios and exposure routes were eliminated from evaluation. Radionuclides were the only contaminants of potential concern identified for Operable Unit 7-01. Curie totals were compiled from the Radioactive Waste Management Information System database and decayed from the time of disposal to the time of evaluation. All contaminants of potential concern were evaluated for the external exposure scenarios using the computer code MICROSIELD to estimate exposure rates to occupational and residential receptors. Input parameters and model output are presented in Burns, Becker, and Jones (1994). Modeling incorporated the assumption that vaults are covered by a minimum of 1.8 m (6 ft) of soil. The Track 2 upper-bound risk estimate for current occupational external exposure is 7E-03 (Burns, Becker, and Jones 1994). Estimated upper-bound risk for the 30-, 100-, and 1,000-year residential external exposure scenarios is 9E-04, 7E-07, and 6E-13, respectively.

Contaminants of potential concern were screened further to evaluate groundwater ingestion risk, based on a calculated 50-year travel time from the soil surface to the water table. Modeling by GWSCREEN (Rood 1994) was performed for isotopes with estimated inventories greater than 1E-10 Ci after 50 years of decay. Groundwater transport parameters, slope factors, and model output are provided in Burns, Becker, and Jones (1994). Estimated upper-bound risk within the 30- to 1,000-year residential evaluation period is 5E-06 for groundwater ingestion.

As a result of the Track 2 scoping activities (Burns, Becker, and Jones 1994), DOE-ID, DEQ, and EPA determined that Operable Unit 7-01 should be included in an RI/FS (DOE-ID 1995). The decision was based on potentially unacceptable risk from direct exposure to ionizing radiation and the need to further evaluate biotic intrusion, erosion, and deposition risk potentials. Because existing data were not sufficient to make final remedial decisions, Operable Unit 7-01 was retained for further evaluation in the Operable Unit 7-14 comprehensive RI/FS.

3.2.2 Operable Unit 7-02, Acid Pit, Track 2 Investigation

The Acid Pit is a 1,900-m² (20,490-ft²) area near the center of the SDA, between Pits 12 and 13, and is roughly rectangular, with dimensions of 60 × 32 m (197 × 105 ft). The Acid Pit was established in 1954 outside the original 13-acre landfill. The pit was excavated down to basalt, which ranged in depth from 4.6 to 6.4 m (15 to 21 ft) below land surface. The basalt then was covered with soil to a thickness of 0.3 to 0.6 m (1 to 2 ft) before disposal operations began. According to the Radioactive Waste Management Information System database, liquid waste was buried in the Acid Pit regularly from 1954 until 1961, and the pit may have received additional waste sporadically until the early 1970s.

(Jorgensen et al. 1994). Final closure operations in 1961 included filling the pit with a soil cover to a minimum thickness of 0.9 m (3 ft) to match the local gradient and planting an overlying vegetation layer of crested wheatgrass. Additional soil up to 0.5 m (1.6 ft) thick has been placed in recent years for routine contouring and subsidence control.

The Acid Pit received liquid organic and inorganic waste. Some of the waste was contaminated with low-level radioactivity. Though records for historical disposals are incomplete, most waste buried in the Acid Pit was probably generated at the INL Site. Personnel interviews and record searches indicate that the liquid waste includes carbon tetrachloride, organic solvents, radiologically contaminated acids, and cleaning solutions. Radiologically contaminated waste probably contains low levels of uranium, Sr-90, Cs-137, Co-60, and TRU isotopes. Typically, liquid waste was poured directly into the pit. Sometimes, lime was added to neutralize acids. Waste disposal records were researched as part of the Acid Pit characterization effort. All records were tabulated from shipping manifests and evaluated under the Track 2 investigation. The complete disposal list appears in the Track 2 Summary Report (Jorgensen et al. 1994).

The Track 2 evaluation (Jorgensen et al. 1994) was conducted before the Track 2 guidance document (DOE-ID 1994d) was available. Uncertainties associated with several parameters required for fate and transport modeling led to numerous conservative assumptions, producing a hazard quotient of 1,210 associated with ingesting mercury-contaminated groundwater. The surrogate mercury compound used in modeling and the distribution coefficient or K_d value used in risk calculations represented a mercury species that is soluble, with virtually no partitioning to subsurface soil (Jorgensen et al. 1994). Based on the Track 2 evaluation, DOE-ID, DEQ, and EPA concluded that the Acid Pit should be investigated further in an RI/FS. The Action Determination (DOE-ID 1994b) was based on uncertainties associated with the hazard quotient of 1,210 for ingesting mercury-contaminated groundwater. At that time, Operable Unit 7-02 was included for additional study and refined risk assessment in the Operable Unit 7-13/14 comprehensive RI/FS.

The K_d s and contaminant concentrations used in the Track 2 investigation were reviewed (Dicke 1997). According to the review conclusion, sample and concentration data indicate that mercury is not mobile in the Acid Pit environment.

While assumptions used in the Track 2 evaluation bounded the risk, results were overly conservative to the degree that they may drive a remedial action for the Acid Pit that is not warranted (DOE-ID 1994b). Substantial evidence supports the conclusion that Acid Pit risk should be assessed in the Operable Unit 7-13/14 comprehensive evaluation by using a more realistic contaminant concentration and a more appropriate K_d (Jorgensen et al. 1994).

Additional studies included assessing the chemical form of mercury in the Acid Pit through secondary ion mass spectrometry (Groenewold 1997), reviewing disposal mass, and identifying a more appropriate K_d . These studies concluded that unidentified chemical forms of mercury in the Acid Pit have limited mobility. Results were used to support the development of the Interim Risk Assessment (IRA) (Becker et al. 1998). As a consequence, mercury was eliminated as a contaminant of potential concern for Waste Area Group 7 and the Acid Pit was eliminated from further evaluation in the Operable Unit 7-13/14 comprehensive RI/FS. Various studies associated with the Acid Pit are summarized in the IRA.

In 1997, a CERCLA treatability study (Loomis, Zdinak, and Jessmore 1998) was conducted at the Acid Pit. Areas of highest mercury concentration were targeted and immobilized by grouting. A 4.3×4.3 -m (14×14 -ft) section near the center of the pit was treated. Average bottom depth in the area was about 4.9 m (16 ft). The lower 2.1 m (7 ft) of the Acid Pit was grouted. A total volume of 12,473 L

(3,295 gal) of grout was applied through 68 penetrations of the subsurface. Following a curing period, 10 core holes were drilled to evaluate success of grouting. Cored material was tested by a toxicity characteristic leaching procedure for mercury and was evaluated for extent of mixing. In general, test results showed that the final waste form passed the leaching procedure test because leachate levels were all lower than regulatory levels. Test values for all cores were in the tens of parts-per-billion range, while the regulatory limit is 200 ppb (Halford et al. 1993). The area was covered with soil and contoured to prevent ponding, after which the area was planted with grass. In 2002, a grout monolith was all that remained of most of the contamination at Operable Unit 7-02. Complete details about the Acid Pit grouting are available in the treatability study report (Loomis, Zdinak, and Jessmore 1998).

3.2.3 Operable Unit 7-03, Nontransuranic-Contaminated Waste Pits and Trenches, Track 1 Investigation

Historical waste disposal records were examined to classify pits and trenches according to the category of waste buried in them. Disposal areas with TRU concentrations greater than 10 nCi/g were assigned to Operable Unit 7-13 and combined with the comprehensive RI/FS as Operable Unit 7-13/14. Those with TRU concentrations no greater than 10 nCi/g were assigned to Operable Unit 7-03 and evaluated according to Track 1 guidance (DOE-ID 1992). The Operable Unit 7-03 Track 1 investigation (INEL 1993a) focused on evaluating existing data for two of the 18 pits and 26 of the 58 trenches, which comprised Pits 7 and 8 and Trenches 18, 21 through 25, 27 through 31, 33, 35 through 38, 40 through 44, 46, 50, 53, 54, 57, and 58. The SVRs were not addressed.

Most of the waste in the non-TRU pits and trenches was generated at the INL Site. Historical disposal practices discussed in Section 3.2 are descriptive of Operable Unit 7-03 disposals. Typically, soil was excavated to basalt, soil underburden was emplaced before the disposal process began, and a final soil cover was added when each disposal site was closed. Opening and closing dates are listed in Figure 3-18, and areas and volumes for each excavation are listed in Tables 3-15 through 3-17.

Radioactive constituents were evaluated in the Track 1 investigation (INEL 1993a). Existing data were not sufficient to quantify risk from nonradioactive hazardous substances, but the Track 1 risk summary report (INEL 1993a) indicated that soil-gas data and other information suggested that contaminants might be migrating from Operable Unit 7-03. Radioactive constituent quantities were taken from the Radioactive Waste Management Information System database and adjusted for decay. The estimated concentration for each contaminant of potential concern was compared to the soil concentration that would generate a $1\text{E-}06$ risk in each standard Track 1 pathway and scenario specified in the Track 1 guidance (DOE-ID 1992). If an estimated concentration was greater than the calculated risk-based soil concentration, a potential unacceptable risk was identified.

Potential unacceptable risk was identified for multiple radioactive constituents in a variety of pathways and scenarios. Therefore, the Action Determination (INEL 1993a), signed by representatives of DOE-ID, DEQ, and EPA, and attached to the Track 1 risk summary, assigned Operable Unit 7-03 for further evaluation in the Operable Unit 7-13 TRU pits and trenches RI/FS.

3.2.4 Operable Unit 7-04, Air Pathway, Track 2 Investigation

Operable Unit 7-04, described as the air pathway, represents an exposure pathway rather than a discrete site. A summary report was not prepared for Operable Unit 7-04. Instead, the Track 2 evaluation was limited to preparing an abbreviated scoping package (INEL 1994a). All the pits, trenches, and soil vaults in the entire SDA were considered in the evaluation, except Pad A, which was assessed under Operable Unit 7-12. Two release mechanisms were addressed: (1) volatilization of VOCs to the

atmosphere and (2) biotic transport of contaminants from waste to the surface followed by suspension of radionuclide-contaminated surface soil.

The Track 2 investigation (INEL 1994a) included only a summary of existing data and previously conducted risk assessments, except for the risk from radon gas. Maximum risk from radon gas was determined to be $3\text{E-}06$. The VOC source-term and risk assessment were taken from the Organic Contamination in the Vadose Zone (OCVZ) RI/FS (Duncan, Sondrup, and Troutman 1993). The remaining source term, consisting of non-VOC hazardous contaminants and inventories of radioactive isotopes, came from a draft version of the Historical Data Task. The Historical Data Task report (INEL 1995a) addressed disposals only through 1983 and did not include Pad A. The risk analysis for the Historical Data Task source term came from the Preliminary Scoping Risk Assessment (Loehr et al. 1994), which was superseded by the Revised Preliminary Scoping Risk Assessment (Burns et al. 1994) for the SDA. The Revised Preliminary Scoping Risk Assessment was based on the modified Historical Data Task inventory. Surface soil concentrations available for windborne transport of fugitive dust were provided by sampling conducted in support of a study of the Operable Unit 7-05 surface water and surficial sediment pathway (Burns, Loehr, and Waters 1993).

Potential risk from VOCs was estimated in the OCVZ RI/FS (Duncan, Troutman, and Sondrup 1993). The OCVZ RI/FS addressed occupational and residential exposure scenarios using standard parameters to estimate carcinogenic and noncarcinogenic risk from VOCs. Potential unacceptable risk was identified for both occupational and residential receptors for inhalation pathways. Though carbon tetrachloride was the only contaminant identified in the Track 2 evaluation with a carcinogenic risk higher than $1\text{E-}06$ or a hazard quotient greater than 1, the OCVZ RI/FS also identified trichloroethylene as a contaminant of potential concern. For the occupational scenario, the maximum inhalation risk and hazard quotient for carbon tetrachloride were $6\text{E-}05$ and 2, respectively. The maximum occupational inhalation risk for trichloroethylene was $4\text{E-}06$. A trichloroethylene hazard quotient could not be estimated because reference doses were not available. The maximum inhalation risk for the residential scenario was $3\text{E-}05$ and $8\text{E-}06$ for carbon tetrachloride and trichloroethylene, respectively. The residential hazard quotient for carbon tetrachloride was 5.

The Preliminary Scoping Risk Assessment modeled biotic transport of nongaseous radionuclides from a waste disposal location to the ground surface followed by suspension and transport of airborne fugitive dust. Residential risk was estimated for 30-year intervals every 100 years from 100 to 1,000 years in the future. Occupational risk was estimated for the 100-year institutional control period (DOE M 435.1-1). Standard Track 2 exposure parameters were applied. The Track 2 Summary Report (INEL 1994a), citing results from Loehr et al. (1994) and Burns et al. (1994), indicated maximum potential risk of $1\text{E-}06$ for Pu-239 and $3\text{E-}06$ for Am-241. Estimated inhalation pathway risk for all other radionuclides was less than $1\text{E-}06$. Details on the risk assessment are available in the Preliminary Scoping Risk Assessments (Loehr et al. 1994; Burns et al. 1994).

Because of the potential unacceptable risk, Operable Unit 7-04 was retained for further evaluation. As stated in the Action Determination (INEL 1995b) attached to the Track 2 evaluation, the air pathway will be assessed in the baseline risk assessment of the Operable Unit 7-13/14 RI/FS.

3.2.5 Operable Unit 7-05, Surface Water Pathways and Surficial Sediments, Track 2 Investigation

Operable Unit 7-05 comprises surficial sediment to a depth of 0.3 m (1 ft) and deeper sediment sequences deposited by surface water run-off within the local drainage basin of RWMC. The Track 2 investigation (Burns, Loehr, and Waters 1993) examined historical data, designed a sample plan based on the historical studies, sampled surficial sediment within Waste Area Group 7, and assessed risk based on the Track 2 samples.

Radionuclide and nonradioactive data were available from previous investigations. Analyses of soil samples for hazardous nonradioactive constituents did not yield evidence of contamination. However, alpha- and gamma-emitting radionuclides were detected at sufficiently high levels to warrant further evaluation (Burns, Loehr, and Waters 1993). Therefore, Track 2 sampling focused on collecting sediment samples from drainage and ponding areas not addressed in previous sampling programs.

Soil samples were collected from 42 locations within Waste Area Group 7 and analyzed for alpha- and gamma-emitting isotopes by spectroscopy. Because beta emitters were not identified as contaminants of potential concern for Operable Unit 7-05, beta analysis was not performed. Alpha-emitting isotopes Pu-239 and Pu-238/Am-241 (i.e., Pu-238 and Am-241 were reported together in the Track 2 investigation) at three of 42 sample locations were detected at concentrations above Track 1 guidance background values (DOE-ID 1992). Compared to the Track 1 Pu-239 background value of 0.13 pCi/g, concentrations ranging from 0.18 to 0.93 pCi/g were detected. The isotopes Pu-238/Am-241 were detected from 0.126 to 0.49 pCi/g compared to the Track 1 background values of 0.0024 pCi/g for Pu-238 and 0.008 pCi/g for Am-241. Concentrations of Th-230 and Th-232 also were detected slightly above background values. Concentrations of all other alpha-emitting isotopes were consistent with background values. One location yielded a Cs-137 concentration of 2.23 pCi/g. The Track 1 background value for Cs-137 is 1.3 pCi/g. All other gamma-emitting isotopes were below background concentrations.

Cesium-137, Pu-239, Pu-238, and Am-241 were considered in the Track 2 risk evaluation for Operable Unit 7-05. Estimated risk from external exposure to Cs-137 for the occupational and residential scenarios was 3E-05 and 2E-05, respectively. Estimated risk for all other contaminants, regardless of exposure scenario or pathway, was less than 1E-06 (Burns, Loehr, and Waters 1993).

Because a potential for unacceptable risk was identified, DOE-ID, DEQ, and EPA retained Operable Unit 7-05 for further evaluation. The Action Determination for Operable Unit 7-05 (DOE-ID 1994e) specified that the surface water pathway (see Section 4 for updated monitoring data) would be assessed in the Operable Unit 7-13 pits and trenches RI/FS and Operable Unit 7-14 comprehensive RI/FS.

3.2.6 Operable Unit 7-06, Groundwater Pathway, Track 2 Investigation

In the Operable Unit 7-06 Track 2 investigation, characteristics of an exposure pathway were examined, rather than potential risk from a discrete source. However, the focus of the Operable Unit 7-06 Track 2 investigation was unique. Rather than estimating potential risk, the evaluation was designed to (1) identify groundwater pathway data gaps, (2) determine optimal data collection schemes to address data gaps, and (3) initiate data-collection programs. Risk from groundwater was evaluated in the Preliminary Scoping Risk Assessments (Loehr et al. 1994; Burns et al. 1994) and in the Track 2 Summary Report (Burgess, Higgs, and Wood 1994). Overall objectives of the Operable Unit 7-06 preliminary scoping discussed in the summary report were (1) to establish a groundwater monitoring network to characterize any contamination migrating from the SDA to the Snake River Plain Aquifer and (2) to determine whether the monitoring network fulfilled regulatory requirements. The Track 2 Summary

Report (Burgess, Higgs, and Wood 1994) discusses previously existing data, analysis of data gaps, Track 2 field work designed to fill data gaps, results, and recommendations for future work. Though the Track 2 Summary Report (DOE-ID 1994c) offers some interpretations of previously existing and newly acquired data, the risk assessment for the groundwater ingestion pathway was deferred to the Operable Unit 7-14 comprehensive RI/FS.

Track 2 groundwater pathway characterization efforts addressed three areas of interest: groundwater, vadose zone, and local geology. Gaps in groundwater data included variability in the direction of groundwater movement (i.e., flow reversals), vertical gradients, effects of fractured basalt preferential flow paths, extent of contamination, and characterization of upgradient contaminant concentrations. Gaps in vadose zone data included extent and distribution of radiochemical, organic, and inorganic contaminants. Gaps in geologic data addressed physical properties of vadose zone media, stratigraphic variability, and thickness of the aquifer.

Six additional aquifer monitoring wells and six vadose zone boreholes were constructed within Waste Area Group 7 to address gaps in groundwater and vadose zone data. Commonly designated the M-series wells, the new aquifer monitoring wells were located next to the six Operable Unit 7-08 OCVZ boreholes to satisfy requirements of both the groundwater Track 2 investigation and the OCVZ RI/FS. In addition, an existing well (i.e., Well USGS-118) was improved to allow monitoring of soil vapor and groundwater. The Track 2 scope included constructing wells, collecting the first round of sample data, and establishing an ongoing monitoring program (see Section 4 for current monitoring results).

To address the geologic data gaps, the Operable Unit 7-06 Track 2 Summary Report (Burgess, Higgs, and Wood 1994) prescribed drilling a continuous corehole to a depth of 365.7 m (1,200 ft) in an upgradient location to the northeast of RWMC. An initial hole, called Corehole C1, was discontinued at a depth of 170.6 m (560 ft). An alternate core, C1A, was completed to a depth of 550 m (1,805 ft) at a distance of 10.4 m (34 ft) from Corehole C1. Plans included caliper, video, natural-gamma, density, neutron, dielectric constant, formation-temperature, magnetic-susceptibility, and resistivity logging by the U.S. Geological Survey (USGS). Though most of the logs were generated, analyses were not completed and documented. However, visual descriptions of the core were used to assess variability of Waste Area Group 7 stratigraphy. Fifty-three individual basalt flows and eight sedimentary interbeds were identified in Coreholes C1 and C1A. Fourteen of the basalt flows and two of the sedimentary interbeds did not appear in both coreholes.

The only exposure pathway associated with Operable Unit 7-06 was groundwater ingestion. Risk for total nitrogen and several radionuclides was identified in the Track 2 investigation, which summarized results of the Preliminary Scoping Risk Assessments (Loehr et al. 1994; Burns et al. 1994). Therefore, Operable Unit 7-06 was retained for further evaluation in the Operable Unit 7-13 pits and trenches RI/FS and the Operable Unit 7-14 comprehensive RI/FS (DOE-ID 1994c).

3.2.7 Operable Unit 7-07, Vadose Zone Radionuclides and Metals, Track 2 Investigation

Potential migration of contaminants through the vadose zone and into the aquifer was addressed in Operable Unit 7-07. Like several operable units in Waste Area Group 7, Operable Unit 7-07 represented an exposure pathway rather than a contaminant source. Groundwater ingestion was the only pathway addressed. Contaminants of potential concern were limited to radionuclides, metal, and specified inorganic compounds. Though Operable Unit 7-07 did not include waste buried in the SDA, contaminants included constituents migrating from buried waste. The Track 2 evaluation was limited to preparing a scoping package (INEL 1994b) that summarized results of the previous groundwater risk assessment

presented in the Preliminary Scoping Risk Assessments (Loehr et al. 1994; Burns et al. 1994). Based on the Historical Data Task, the Preliminary Scoping Risk Assessments were limited to disposals through 1983. According to the Operable Unit 7-07 Track 2 Preliminary Scoping Report (INEL 1994b), Pad A inventories and disposals after 1983 would be evaluated in the Operable Unit 7-13/14 comprehensive RI/FS.

The Preliminary Scoping Risk Assessments were based on contaminant release and transport modeling rather than detected contaminant concentrations from vadose zone samples. The modeling did not implement the Track 2 risk assessment methodology, which incorporates the assumption that all contaminants are available for immediate release to the environment. Instead, the Preliminary Scoping Risk Assessments applied differential-release modeling that accounted for containment and the physical and chemical forms of waste. The DUST computer code (Sullivan 1992) was used to model various release mechanisms (i.e., surface-to-water partitioning, metal corrosion, and equilibrium solubility of liquid and solids). Buried waste, though not included in the definition of Operable Unit 7-07, constituted the source volume and area used for contaminant-release modeling. Transport through the vadose zone into the aquifer was modeled with GWSCREEN (Rood 1994) using the source mass flux from the DUST model. Simulations estimated peak groundwater concentrations, regardless of time.

Residential risk from ingestion of contaminated groundwater was evaluated for two periods following 100 years of institutional control, as defined in DOE M 435.1-1: 100 to 1,000 years in the future and after 1,000 years. Standard EPA default parameters were used to calculate intake and exposure. Groundwater risk for 19 radioisotopes, beryllium, cadmium, mercury, and total nitrogen (i.e., the sum of contributions from various nitrogen compounds, including nitrate, nitric acid, and ammonia) were evaluated. Risk was below $1\text{E-}06$, and hazard quotients were less than 1 for beryllium, cadmium, and mercury. A hazard quotient of 2 was estimated for total nitrogen, but the maximum concentration in groundwater was predicted to occur at least 50 years before the end of the 100-year institutional control period assumed for the assessment. The simulated hazard quotient was $4\text{E-}07$ at the end of 100 years. Therefore, metal and nitrogen compounds were not identified as groundwater risk drivers. However, risk estimates were greater than $1\text{E-}06$ for several radioisotopes. Risk estimates for C-14, I-129, and Tc-99 were $4\text{E-}03$, $1\text{E-}02$, and $1\text{E-}04$, respectively, for the 100-to-1,000-year period. Risk estimates between $1\text{E-}04$ and $1\text{E-}06$ were observed for Am-241, Ni-59, Np-237, U-234, U-235, and U-238 for the post-1,000-year period.

Empirical evidence supported the conclusion from modeling results that contaminants could be migrating. Observations and analytical data from the 1974 Initial Drum Retrieval Project indicated minimal radiological contamination (see Section 3.1.5.3). The 1976 Early Waste Retrieval Project indicated that many buried drums had lost integrity. Soil samples yielded positive detections of Pu-239/240, Am-241, and Cs-137 in the soil beneath the waste and above the first basalt interface (see Section 3.1.5.4). Boreholes also were drilled and sampled intermittently between 1971 and 1987. A total of 273 samples at various depths within the vadose zone, down to the C-D interbed (approximately 73 m [240 ft]), were statistically analyzed (Dames & Moore 1994). Vadose zone background values were developed by analyzing samples from six wells located outside the SDA. Analytical results from vadose zone sediment samples from 32 wells within the SDA were evaluated to determine whether radionuclides were migrating downward from the buried waste. Data supported the conclusion that anthropogenic Am-241, Pu-238, Pu-239/240, and U-235 existed in the vadose zone, though detection frequencies were low (see Section 4) for updated monitoring results. Operable Unit 7-07 was retained for further evaluation in the Operable Unit 7-14 comprehensive investigation, based on the Track 2 evaluation (INEL 1994b).

3.2.8 Operable Unit 7-08, Organic Contamination in the Vadose Zone Remedial Investigation and Feasibility Study

Organic contamination in the vadose zone was identified for an RI/FS in Operable Unit 7-08 (DOE-ID 1994f) in the FFA/CO. The OCVZ RI/FS addressed organic vapors that had been released from SDA disposal pits and trenches and migrated from land surface down to the top of the Snake River Plain Aquifer, which is at a depth of approximately 177 m (580 ft). The OCVZ RI/FS addressed releases from containerized Series 743 sludge^e (Duncan, Troutman, and Sondrup 1993). The amount of VOCs in Series 743 organic waste was originally estimated by Kudera (1987) to be 334,627 L (88,400 gal) composed of approximately 171,328 L (45,260 gal) of Texaco Regal Oil, 92,413 L (24,413 gal) of carbon tetrachloride, and 70,886 L (18,726 gal) of miscellaneous organic compounds. Analysis of data obtained after the OCVZ RI/FS resulted in a much larger source estimate for carbon tetrachloride (i.e., $4.92\text{E}+05$ L [$1.30\text{E}+05$ gal]) (Miller and Varvel 2005).

In the OCVZ RI/FS (Duncan, Troutman, and Sondrup 1993), both existing and newly acquired data were considered that showed VOCs had been detected in soil vapor, surficial soil, perched water, and the aquifer. Interpretation of sample data supported the conclusion that VOCs were migrating from disposal pits into the vadose zone and continuing to move both laterally and vertically in the subsurface. Concentrations of carbon tetrachloride have been detected above the maximum contaminant level (MCL) in the aquifer near the SDA. The baseline risk assessment portion of the OCVZ RI/FS addressed occupational and residential exposure scenarios for three intervals: the current industrial period (1992 through 2021), the institutional control period (1992 through 2091), and the post-institutional control period (2092 through 2121). Carcinogenic risk greater than $1\text{E}-06$, but less than $1\text{E}-04$, was estimated for all three periods for both occupational and residential exposures. Hazard quotients for noncarcinogenic effects, particularly from inhalation and ingestion of contaminated groundwater, were much more significant. Estimated hazard quotients were as high as 6 for resident children during the modeled 100-year institutional control, 5 for post-institutional resident children, and 2 for current workers. Additional information is contained in the OCVZ RI/FS (Duncan, Troutman, and Sondrup 1993).

Considered in conjunction with VOC concentrations detected in perched water and aquifer samples, the results of the OCVZ RI/FS supported a decision to remediate organic compounds in the vadose zone. A vapor vacuum extraction treatability study was conducted in 1993 to evaluate technology for vapor vacuum extraction for application at the SDA (Lodman et al. 1994). The study included several tests to optimize performance of vapor vacuum extraction and to evaluate hydrologic characteristics of the vadose zone. The study successfully demonstrated that VOCs were effectively captured from extracted vapor using carbon adsorption beds. The 1993 demonstration recovered approximately 1,340 kg (2,900 lb) of VOCs (Lodman et al. 1994). The vapor vacuum extraction method was compared to other remedial options and was selected as the remedial alternative for OCVZ.

Completing the OCVZ RI/FS eventually led to the Operable Unit 7-08 ROD (DOE-ID 1994f). The ROD specified remediating the OCVZ by extracting and destroying these organic contaminant vapors and monitoring the vadose zone and aquifer.

e. The waste is called Series 743 sludge because it was processed into sludge in Rocky Flats Plant Building 774 and was later coded at the INL Site as Content Code 3 organic waste to distinguish it from other types of waste from the Rocky Flats Plant Building 774 shipped to the INL Site.

Major components of the selected remedy include the following:

- Installing and operating five vapor extraction wells (in addition to an existing vapor extraction well) at RWMC as a part of Phase I operations. The selected remedy includes options to expand the number of vapor extraction wells during Phase II and III operations.
- Installing and operating off-gas treatment systems to destroy the organic contaminants in vapor removed by the extraction wells.
- Adding soil-vapor sampling wells to monitor performance of the remedy and verify attainment of Operable Unit 7-08 remedial action objectives. Soil-vapor monitoring also will provide information to evaluate the requirement for potential modifications to the selected remedy as treatment proceeds.

Objectives of the selected remedy are to reduce the human health and environmental risk associated with organic contaminants in the vadose zone and to prevent exceeding federal and state drinking water standards. The selected remedy does not address buried waste in the SDA. The remaining buried waste could extend the timeframe required to achieve remedial action objectives, using the selected remedy, because the remaining organic mass could act as a long-term source of vadose zone organic contamination (DOE-ID 1994f). Because carbon tetrachloride had been detected above the MCL before the selected remedy started, additional wells were planned to characterize the extent of VOCs in the vadose zone and aquifer beneath and surrounding the SDA.

The primary remedial action objective, as identified in the Operable Unit 7-08 ROD (DOE-ID 1994f), is to ensure that risk to future groundwater users is within acceptable guidelines and that future contaminant concentrations in the aquifer remain below federal and state MCLs. From a regulatory standpoint, the point of compliance for the OCVZ Project is the Snake River Plain Aquifer outside the SDA boundary. Organic chemical concentrations in groundwater cannot serve as a direct indication that the remedy may be shut down because of the time delay for the contaminants to migrate from the vadose zone into the groundwater; therefore, the project established remediation goals in the vadose zone in the form of vapor concentrations. Remediation goals are defined as allowable vapor concentrations in the vadose zone such that MCLs at the point of compliance are not exceeded. Updated remediation goals were published in the Operable Unit 7-08 Data Quality Objectives Summary Report (INL 2005).

A vapor vacuum extraction with treatment system, comprising three treatment units and extracting from up to five wells, was constructed and began operating in January 1996. Since the beginning of Phase I operations in January of 1996, through June 30, 2005, approximately 91,474 kg (201,666 lb) of total VOCs have been removed and treated. The approximate total VOCs removed are:

- 55,090 kg (121,453 lb) of carbon tetrachloride
- 18,876 kg (30,591 lb) of chloroform
- 3,769 kg (8,309 lb) of tetrachloroethylene
- 13,928 kg (30,706 lb) of trichloroethylene
- 4,811 kg (10,607 lb) of 1,1,1-trichloroethane.

Initially, extraction was to be conducted in three 2-year phases. Though progress toward achieving cleanup goals has been realized, the original schedule appears to have been overly optimistic, necessitating extensions for Phase II and III operations. One primary reason for the extension is that active releases from buried waste are still occurring.

The original vapor vacuum extraction and treatment system has been upgraded substantially by adding 17 new extraction wells (14 in 2002) and replacing the three original treatment units (i.e., A, B, and C). The original propane oxidizers were replaced with electrically heated catalytic oxidation systems. Unit D was deployed in 2001, and Units E and F began operation in spring 2004. The three catalytic oxidizers have an operating capacity of 500 scfm and are extracting subsurface vapors from multiple wells.

As described in the Operable Unit 7-08 ROD, the Operable Unit 7-08 remedial action is designed to add phases, as needed, to ensure the selected remedy achieves remedial action objectives. The original intent was to operate the system for 2 years, evaluate system performance, and modify and improve the system, as necessary. The ROD stated that actual duration of each phase would depend on activities such as procuring and installing equipment that may be involved with each potential phase transition. In addition, organic waste remaining in the pits could extend the timeframe required to achieve remedial action objectives using the selected remedy because the remaining organic waste could act as a long-term source of organic contamination in the vadose zone. Operations and monitoring for Phase II are expected to continue until active extraction is no longer required to ensure that remedial action objectives will be met. Project life-cycle planning incorporates the assumption that the source of organic contamination will be eliminated or reduced such that active extraction from the vadose zone beneath the SDA will not be required beyond the year 2018. This estimate is based on the following assumptions:

- The Operable Unit 7-13/14 ROD will be finalized in the year 2008.
- The selected remedy for Operable Unit 7-13/14 will be implemented in the year 2010.
- The selected remedy for Operable Unit 7-13/14 will reduce or eliminate the source of organic contamination by the year 2012.
- Once the source of organic contamination is reduced or eliminated (i.e., buried waste is treated or removed), no more than 7 years (i.e., 2012 to 2018) will be required to extract and treat organic vapors remaining in the vadose zone. Monitored vapor concentrations must satisfy conditions required for shutdown of active extraction (INL 2005).

Once active extraction is shut down, the remedial action will transition into Phase III. During Phase III, a compliance verification phase will be implemented to determine whether resuming operations is warranted. The compliance verification phase will last a minimum of 1 year, and may take up to 4 years to complete (i.e., 2019 to 2022). Upon completing the compliance verification phase, the long-term monitoring phase will begin. During the long-term monitoring phase, the vapor vacuum extraction with treatment system will remain shut down, and vapor monitoring will be conducted less frequently.

3.2.9 Operable Unit 7-09, Transuranic Storage Area Releases, Track 1 Investigation

The Action Plan attached to the FFA/CO (DOE-ID 1991) identified Operable Unit 7-09 has historically released contaminants from the TSA to the environment. Therefore, the source term for this operable unit is not the waste stored at the TSA. All waste accumulated at the TSA eventually will be retrieved and moved to WIPP or another approved permanent federal repository. The Track 1 investigation (INEL 1993a) considered the risk potential from radionuclide, organic, and inorganic contamination from possible secondary sources (e.g., asphalt and soil) that may have been contaminated by past releases.

The TSA contains TRU waste in boxes and drums stacked on asphalt pads; on TSA Pad R, the waste is covered with earth as well. The only evidence of contaminant release from the TSA was

discovered in April 1988 during a routine transfer of a waste box from TSA Pad R to the now-decommissioned Certification and Segregation Building (WMF-612) at RWMC. A breached box was discovered, and subsequent radiological surveys revealed alpha contamination on surfaces of some other waste boxes, the asphalt floor on part of Pad R, and part of the floor of WMF-612. The breached box was resealed, contaminated box surfaces were decontaminated, and contamination was fixed in place on the asphalt using surface sealers. During radiological surveys and inspections that followed, two other breached boxes were discovered and similar cleanup actions were taken.

A soil-gas survey conducted over TSA earthen berms detected elevated concentrations of volatile organics in noncontiguous areas on the edges of the survey area. These data suggested some volatilization of organics to the atmosphere from waste stored at the TSA. As part of the OCVZ remedial action, a monitoring well was drilled between the SDA and the TSA to determine whether historical TSA releases may have contributed to the volatile organic plume detected during soil-gas surveys. Data were not conclusive.

The Track 1 investigation (INEL 1993a) concluded that no apparent unacceptable risk was generated by historical releases of contaminants; however, sufficient uncertainty existed about cleanup of Pad R and potential VOCs in TSA soil to retain Operable Unit 7-09 for further evaluation in the Operable Unit 7-14 comprehensive RI/FS.

Subsequently, DOE-ID, DEQ, and EPA determined that evaluation of Operable Unit 7-09 should be deferred until TSA operations have been terminated and the facility has been closed under RCRA (DOE-ID 1998b). The strategy is to identify target analytes for soil samples collected under the RCRA closure action in cooperation with DOE-ID, DEQ, and EPA under the CERCLA program and to determine an appropriate CERCLA response based on the results. Furthering this logic, Operable Unit 7-09 has been excised from Operable Unit 7-13/14.

In 1996, British Nuclear Fuels Limited was awarded a privatized, fixed-price contract by DOE-ID to design, build, and operate the Advanced Mixed Waste Treatment Project at RWMC. The purpose of the Advanced Mixed Waste Treatment Project is to retrieve, characterize, treat, and package approximately 65,000 m³ (85,000 yd³) of TRU waste stored above ground in the TSA for shipment to WIPP for final disposal. Construction and testing were completed by March 28, 2003, when DOE-ID authorized retrieval and characterization of waste to begin at the treatment plant (BNFL 2003a). Shipment of TRU waste to WIPP commenced on April 1, 2003 (BNFL 2003b). The DOE-ID purchased British Nuclear Fuels Limited's interest in the Advanced Mixed Waste Treatment Project in February 2005; on May 1, 2005, DOE-ID awarded a 1-year contract to Bechtel BWXT Idaho, LLC, to continue retrieval, characterization, treatment, and packaging of TRU waste for shipment to WIPP (AMWTP 2005). The WIPP deployed their Central Characterization Project equipment and personnel to the INL Site in 2004 to expedite shipment of TRU waste to WIPP. Central Characterization Project equipment is designed to characterize TRU waste and meets stringent WIPP waste acceptance requirements for characterization necessary to dispose of TRU waste at WIPP. Eventually, Central Characterization Project equipment will be used to characterize and certify all TRU waste shipped from the SDA to WIPP.

3.2.10 Operable Unit 7-10, Pit 9 Process Demonstration Interim Action

Operable Unit 7-10 encompasses Pit 9, a disposal pit that was active from November 1967 through June 1969. Pit 9 is located in the northeastern corner of the SDA (see Figure 3-1); it comprises approximately 0.4 ha (1 acre) and is roughly trapezoidal in shape, with areal dimensions of 115 × 40 m (379 × 127 ft) (McClellan, del C. Figueroa, and King 1991). The average depth to basalt within Pit 9 is 5.3 m (17.5 ft). The original excavation was completed to basalt and then backfilled with approximately 1.1 m (3.5 ft) of soil before disposal operations commenced. The pit contains approximately 7,080 m³

(250,000 ft³) of overburden, 4,250 m³ (150,000 ft³) of packaged waste, and 9,910 m³ (350,000 ft³) of underburden and interstitial soil (DOE-ID 1993).

Between February and September 1968, waste shipments containing VOCs, TRU radionuclides, and metal were transported from Rocky Flats Plant for burial in Pit 9. Pit 9 also received waste shipments from various INL Site facilities while the pit was open (DOE-ID 1993).

Rocky Flats Plant waste included drums of sludge contaminated with a mixture of TRU elements and organic solvents, boxes of assorted solid waste, and cardboard boxes containing empty contaminated drums (DOE-ID 1993). Rocky Flats Plant waste in Pit 9 contains approximately 29 kg (64 lb) of plutonium and 0.94 kg (2 lb) of americium (Einerson and Thomas 1999). Backfill soil was placed over the waste after each disposal, and a final soil layer up to about 1.8 m (6 ft) thick covers the entire pit.

In a preliminary risk evaluation of Pit 9 (McClellan, del C. Figueroa, and King 1991), upper-bound risk was estimated for only the occupational scenario. Because this preliminary risk modeling did not reflect physical conditions at Pit 9, subsequent evaluations relied on soil and water sample data to describe the nature and extent of contamination (DOE-ID 1992).

Trace amounts of plutonium and americium were detected in the subsurface at the SDA (DOE-ID 1993). Aquifer samples yielded detectable concentrations of carbon tetrachloride, chloroform, 1,1,1-trichloroethane, and trichloroethylene. With the exception of carbon tetrachloride, all detected groundwater concentrations were less than the MCLs. On August 11, 1987, analysis detected 6 mg/L of carbon tetrachloride in Well USGS-090, which was slightly above the 5-mg/L MCL (Mann and Knobel 1987).

A combination of physical separation, chemical extraction, and stabilization to recover contaminants and reduce the source of contamination is specified in the Pit 9 ROD (DOE-ID 1993), which documented the preferred remedial alternative. Implementing the preferred alternative, according to the Pit 9 ROD, was contingent on successful demonstration that cleanup criteria and other performance objectives could be met.

The initial effort to implement the Operable Unit 7-10 ROD was through a fixed-price, privatized subcontract with Lockheed Martin Advanced Environmental Systems. Based on difficulties during the design and construction phase, original Operable Unit 7-10 milestones were missed, and project delays resulted. The delays led to an informal dispute resolution process under the FFA/CO for Operable Unit 7-10 that was conducted in 1997. A revised path forward for the project, consisting of contingency planning, was reached through the dispute process. The contingency plan was prepared to accomplish the agreed-to scope of work and was documented in a revised Remedial Design/Remedial Action Scope of Work (INEEL 1997) and a subsequent Explanation of Significant Differences (DOE-ID 1998a). The revised Remedial Design/Remedial Action Scope of Work and Explanation of Significant Differences outline a three-staged approach for Pit 9:

- **Stage I**—A subsurface sampling phase, which in part was to be used for determining the location of the Stage II effort within the Pit 9 area and subsurface exploration to obtain material for bench-scale studies and allow for characterization.
- **Stage II**—Excavation and retrieval of TRU waste from a 6.1 × 6.1-m (20 × 20-ft) area within Pit 9. A remedial action report describing how cleanup objectives established by the Operable Unit 7-10 ROD were met would be completed at the conclusion of Stage II. The limited retrieval and excavation would be conducted to obtain material for pilot-scale treatability studies, in situ and ex situ treatment tests, and characterization of waste and soil.

- **Stage III**—Full-scale excavation and retrieval of TRU waste in the entirety of Pit 9.

Stage I objectives outlined in the 1997 Remedial Design/Remedial Action Scope of Work and the Explanation of Significant Differences (DOE-ID 1998a) were effectively met with the selection of the location for the Stage II demonstration retrieval area. Stage I consisted of two phases: Phase I involved installing probes and downhole geophysical logging, and Phase II involved coring, sample retrieval and analysis, and bench-scale treatability studies.

Stage II implementation was initiated in 1997, leading to submittal of a draft 90% design^f in accordance with the enforceable deadline in June 2000. The 90% design for Stage II was submitted to the regulatory agencies on June 15, 2000, as part of the Remedial Design/Remedial Action Scope of Work for Stage II (INEEL 1997).

While the Stage II design met all technical requirements, the associated schedule did not meet the enforceable deadline for completing the remedial action report. Though DOE requested a schedule extension under the FFA/CO, the request was denied by the regulatory agencies, resulting in a formal dispute in accordance with provisions of the FFA/CO. As part of the dispute-resolution process, alternate concepts to demonstrate retrieval were developed. The alternate concepts focused on using simpler methods and shortening overall duration of the retrieval demonstration. In some cases, overall project objectives had to be modified from those of the original Stage II mission. The resulting concepts were documented in INEEL (2001). The concept selected was the glove box excavator method. Through an Agreement to Resolve Disputes (DOE 2002), the regulatory agencies formally adopted the glove box excavator method for accomplishing the Stage II mission and established new enforceable milestones for implementing the Pit 9 process demonstration, including future commencement of operations for Stage III. The Pit 9 Agreement to Resolve Disputes (DOE 2002) required completing the following activities and schedule, which superseded previous FFA/CO milestones for Operable Unit 7-10:

- **Stage II**
 - Submit Notification of Critical Decision 2/3, approval to proceed to procurement and construction, by no later than August 30, 2002
 - Submit Stage II remedial design (completed project design) by no later than October 31, 2002
 - Commence construction of Stage II by no later than November 30, 2002, and submit notification to DEQ and EPA of commencement of construction: “substantial continuous onsite physical construction”
 - Submit notification of Critical Decision 4 (operations phase) by February 28, 2004
 - Commence Stage II excavation, implement “substantial continuous onsite physical waste retrieval and packaging operations” by March 31, 2004, and notify DEQ and EPA accordingly
 - Complete Stage II excavation by October 31, 2004, and submit a draft remedial action report.

f. The 90% design was presented in a draft remedial design document that was never finalized, “Draft Operable Unit 7-10 (OU 7-10) Staged Interim Action Project, Stage II, Remedial Design and Remedial Action Work Plan Primary Deliverable Submittal,” Binder I-A, “Remedial Design/Remedial Action Work Plan for Stage II of the Operable Unit 7-10 (OU 7-10) Staged Interim Action Project,” DOE/ID-10767.

- Stage III
 - Submit Stage III 10% design by September 2005
 - Complete remedial design for Stage III, and commence construction by March 31, 2007
 - Commence Stage III operations within 6 months of construction.

The regulatory agencies agreed to extend the milestone to complete remedial design and commence construction for Stage III to March 31, 2008 (DOE 2004). The milestone to submit the Stage III 10% design by September 2005 was met through the ongoing removal action in Pit 4 of the SDA. In August 2004, the regulatory agencies signed an action memorandum (DOE-ID 2004c) to conduct a non-time-critical removal action for limited excavation and retrieval of selected waste streams from an approximate 0.2-ha (0.5-acre) plot in the eastern portion of Pit 4. Waste in this area is primarily from Rocky Flats Plant. The area was selected by DOE, DEQ, and EPA, based on inventory evaluations identifying significant quantities of TRU and other contaminated waste buried in the area. The project is referred to as the Accelerated Retrieval Project.

The status of work completed on Stages I, II, and III is delineated in the next subsections.

3.2.10.1 Stage I Phase I Progress. In the first phase of Stage I, a 12 × 12-m (40 × 40-ft) study area was selected to meet the objectives of Stage I, based on a review of inventory records and results of geophysical surveys of the pit. A historical record search was conducted, including earlier studies of surface geophysical characteristics, to identify areas of the pit most likely to contain the target Rocky Flats Plant waste. Results of this search led to selection of the 12 × 12-m (40 × 40-ft) study area in the southwestern portion of Pit 9 as the site for Stage I probing and coring activities.

Completed Stage I activities are listed below:

- Project objectives and data quality objectives were developed to define Stage I activities.
- Noninvasive geomagnetic techniques were used to identify significant concentrations of ferrous material (e.g., drums or drum residue) within Pit 9. Based on analysis of this information, an area of high metallic concentration was selected as the study area for the project.
- In December 1999, a commercially available sonic drill rig was used to drive pointed steel casings into the designated area of Pit 9. In the initial campaign, 20 of these casings, referred to as Type A probes (see Section 3.6.4), were driven through the soil and waste until refusal occurred. These probe holes provided access for placing logging instruments inside the casing at various depths.

Subsurface geophysical and radiation-detection logging in the cased probe holes were completed. Instruments used to perform the logging were passive gamma and passive neutron detectors for identifying Pu-239 and other TRU radionuclides; a shielded, directional, passive gamma detector to identify the azimuthal location of gamma-emitting sources; a neutron-gamma (i.e., n-gamma) tool to detect prompt gamma rays from chlorine (a potential indicator for halogenated hydrocarbons); and a neutron-neutron soil-moisture gauge to measure moisture content of soil.

Two additional probing campaigns were completed in 2000. The first campaign was located on the eastern side of the pit in an area determined from shipping records to include graphite debris. The second was in the northern half of the pit in an area determined from shipping records to include ventilation filters.

The following observations and conclusions were developed, based on analysis of the information gained during this probing campaign:

- Vertical waste zone boundaries can be estimated within approximately 30.5 cm (1 ft).
- Measurements of plutonium and americium correlate reasonably well with disposal records.
- High concentrations of radionuclides are easily measured.
- Probing resolves some of the ambiguities in current geophysical data. Specifically, geophysical data indicate the probable location of metal drums, but no indication of the contents. Probing data unambiguously identify overburden and waste regions in the vicinity of each probe hole. In addition, logging provides indications of the depths of the waste.
- Under certain conditions (i.e., absence of interfering signals from multiple waste forms within the detection range of the sensors), specific waste forms can be identified.
- Chlorine can be located at concentrations exceeding 300 ppm and 20 wt%.
- Measurements of soil moisture above and below the waste zone can be accurately determined.

3.2.10.2 Stage I Phase II Progress. The second phase of Stage I was to obtain core samples from six locations selected from the results of Phase I. Activities completed included development of the Technical and Functional Requirements (INEEL 2002), Preliminary Safety Assessment (INEEL 1999), design-disclosure documents, and mockup testing of specific parts. In April 2000, work on the coring system was discontinued in favor of an alternate probehole method identified by Operable Unit 7-13/14 to acquire similar data (see Section 3.6). Instrumented probes were used to obtain information from waste in the SDA.

3.2.10.3 Stage II Progress. The Remedial Design Package for the Operable Unit 7-10 Project (DOE-ID 2002) was submitted to DEQ and EPA on October 1, 2002, identifying the glove box excavator method as the approach to be implemented.

The Operable Unit 7-10 Glovebox Excavator Method Project retrieval system consisted of the fabric Weather Enclosure Structure, the steel Retrieval Confinement Structure, a standard excavator, a ventilation system, and other supporting equipment. The excavator boom and bucket were inside the steel Retrieval Confinement Structure, while the operator and other excavator components were outside the Retrieval Confinement Structure but inside the fabric Weather Enclosure Structure. Locating the excavator operator and material packaging and handling personnel outside the Retrieval Confinement Structure reduced worker radiological and chemical exposure and risk.

Remedial action operations and maintenance activities for implementing Stage II of the Operable Unit 7-10 interim action included overburden removal, waste retrieval, underburden sampling, waste-drum storage, data collection and analysis, maintenance, and facility monitoring. Overburden removal began on December 12, 2003. Waste zone retrieval operations began on January 5, 2004. On February 24, 2004, DOE-ID notified DEQ and EPA of the completion of waste retrieval for the project. Section 3.1.5.6 summarizes the glove box excavator method retrieval.

During retrieval, excavator operators took scoops of waste zone material and placed them in transfer carts at one of three glove boxes. Glove box operators moved the transfer carts into the glove boxes, segregated the waste zone material, separated and measured suspect fissile material, and packaged

waste in appropriate storage containers (i.e., 55-gal drums) in a safe and compliant manner. When operators suspected fissile material in the waste, the suspect material was placed in a separate bucket and moved to a fissile material monitor for measurement and subsequent placement in an appropriate drum, ensuring that criticality limits were never exceeded. Once the drums were filled, operators changed out drums and transferred them for assay measurement and then to interim storage in WMF-628, Type II Storage Module #1. Composite samples were analyzed to support application of hazardous waste numbers. Each drum identification number was entered into the Integrated Waste Tracking System.

A total of 454 drums were filled during retrieval. Of the 454 drums, 60 were identified with TRU concentrations greater than 100 nCi/g (DOE-ID 2004b), and most of the drums contained approximately 0.14 m³ (5 ft³) of waste material, thus meeting a project objective of removing more than 2.12 m³ (75 yd³) of material. Waste drums found in the pit had little structural integrity due to corrosion. However, plastic bags and plastic containers had retained much of their integrity. Some bags were more brittle than others, but most were in extremely good condition. Text on plastic containers and labels protected by plastic was often still clear and legible. Operators removed six underburden cores from the interface of the waste zone and underburden. Cores contained in Lexan tubes were removed from the core barrel, bagged out of the Retrieval Confinement Structure, and shipped to a laboratory at INTEC for analysis. Project completion was documented through submittal of the final Remedial Action Report for the Operable Unit 7-10 (DOE ID 2004b) in November 2004.

Some of the data collected during the Operable Unit 7-10 Glovebox Excavator Method Project are presented in the Operable Unit 7-10 Remedial Action Report (DOE-ID 2004b). Data collection was performed as defined in the Field Sampling Plan for Operable Unit 7-10 (Salomon et al. 2003). The data primarily include radiological assay and solids sampling of retrieved waste and soil, sampling of underburden soil, and collection of various biased samples, including biased samples of selected Rocky Flats Plant-series sludge to support characterization and testing efforts of Operable Unit 7-13/14 (see Section 3.8). Data also were collected to quantify radiological emissions from the HEPA-filtered exhaust stack.

Biased and composite sampling of waste zone material (i.e., soil and waste solids) was performed in the designated excavation area of Pit 9. The composite waste zone sampling process required collecting small incremental subsamples from each cart used to fill each drum in a five-drum campaign. Subsamples from all carts used to fill five drums were composited into one sample representing the five-drum campaign. The sampling strategy was designed to provide a very accurate estimate of the population mean because every drum contributes to the estimate by contributing to a five-drum composite.

In addition, samples were collected on behalf of Operable Unit 7-13/14. Some of these samples were subjected to laboratory analysis in relatively pure form (see Section 3.8), while others were composited and used to support bench-scale studies. Information gathered through performance of the Operable Unit 7-10 Glovebox Excavator Method Project was factored into design planning for the Accelerated Retrieval Project. Data obtained from completion of Stage II provide information relevant to predicting impacts from future retrieval operations as they pertain to occupational exposures, waste classifications for disposition, and air emissions estimates. These data support development of the Operable Unit 7-13/14 feasibility study.

3.2.10.4 Stage III Progress. Stage III activities are outlined in the Remedial Design/Remedial Action Scope of Work (INEEL 1997) and the Explanation of Significant Differences (DOE-ID 1998a) for Operable Unit 7-10. Implementing work scope directly related to Stage III inherently depends on completing Stages I and II and upon implementing removal action activities within Pit 4 under the Accelerated Retrieval Project.

3.2.11 Operable Unit 7-11, Septic Tanks and Drain Fields, Track 1 Investigation

Operable Unit 7-11 comprises three septic systems within RWMC, two in the administrative area and one within the TSA. All three systems received sanitary waste discharges from various buildings in administrative control areas of RWMC. All septic systems were analyzed for radiological constituents (e.g., barium, methyl ethyl ketone, and cresols) as part of the Track 1 investigation. No radiological contamination was detected, and all detected constituents were below regulatory limits. Therefore, the Track 1 investigation concluded that the septic systems do not pose any significant risk. A No Further Action Determination (INEL 1993c) was signed, and Operable Unit 7-11 was eliminated from further study in the Operable Unit 7-14 comprehensive RI/FS.

3.2.12 Operable Unit 7-12, Pad A, Remedial Investigation and Feasibility Study

Pad A is an aboveground asphalt pad that measures 73×102 m (240×335 ft) and varies from 5 to 7.6 cm (2 to 3 in.) in thickness. Pad A was constructed for disposal of packaged solid mixed waste (i.e., hazardous waste contaminated with radioactive material), primarily from Rocky Flats Plant. Originally called the Engineered Waste Storage Area, this pad was later called the Transuranic Disposal Area, and is now known as Pad A. The pad was constructed in 1972 within the SDA in an area unsuitable for subsurface disposal because of shallow surficial sediment.

More than 20,000 waste containers, including 18,232 55-gal drums and 2,020 $1.2 \times 1.2 \times 2$ -m ($4 \times 4 \times 7$ -ft) plywood boxes, were placed on the pad between September 1972 and August 1978. Most containers were double-lined with polyethylene, but some containers were only single-lined. Approximately 40% of the pad was covered with waste when Pad A was closed in 1978 (DOE-ID 1994a).

Pad A contains primarily nitrate salts, depleted uranium, and sewage sludge. Specific components of the approximately $10,200 \text{ m}^3$ ($13,341 \text{ yd}^3$) of waste are listed below:

- About $7,250 \text{ m}^3$ ($9,483 \text{ yd}^3$) of evaporator salts, primarily sodium nitrate and potassium nitrate, from Rocky Flats Plant that are contaminated with less than 10-nCi/g levels of TRU isotopes
- Approximately $2,250 \text{ m}^3$ ($2,943 \text{ yd}^3$) of waste from Rocky Flats Plant, consisting primarily of uranium oxides, uranium castings waste, beryllium foundry waste, and machining waste, which is a mixture of depleted uranium and beryllium foundry waste
- Dry sewage from Rocky Flats Plant that is contaminated with less than 10 nCi/g levels of TRU isotopes
- Miscellaneous INL Site-generated radioactive waste (e.g., laboratory waste, radiological instrument counting sources, and uranium standards).

Miscellaneous waste at Pad A includes salt, soil, concrete, and other types of material. Evaporator salts (i.e., nitrate) have been reviewed against “Identification and Listing of Hazardous Waste” (40 CFR 261.21[a][4]) and “Experimental Use Permits” (49 CFR 172.151) and exhibit properties of an oxidizer and, therefore, can have the characteristic of ignitability. The radionuclides include plutonium, americium, thorium, uranium, and K-40. All but two waste shipments disposed of on Pad A contained TRU alpha-emitting radioisotopes with concentrations less than 10 nCi/g and exposure rates less than 200 mR/hour at the container surface. The other two shipments, consisting of 10 drums, contained waste with concentrations greater than 100 nCi/g (DOE-ID 1994a).

According to information from the Radioactive Waste Management Information System, about 4,600,787 kg (10,143,000 lb) of inorganic salt from Rocky Flats Plant is contained in 1,275 plywood boxes and 15,400 drums at Pad A. The total inorganic salt waste consists of approximately 60% sodium nitrate, 30% potassium nitrate, and 10% chloride, sulfate, and hydroxide salt. The salt comprises 71% of the total waste volume at Pad A (MK 1994).

The Pad A RI/FS (Halford et al. 1993) consisted mainly of compiling, documenting, and evaluating existing data because substantial monitoring, sampling, and drum retrieval information was available. The risk assessment identified the potentially unacceptable future scenario risk from ingestion of nitrate-contaminated groundwater by sensitive receptors (e.g., infants and children).

Documented in the Pad A ROD (DOE-ID 1994a), the remedial action selected for Pad A included limited action consisting of augmenting and shaping the existing soil cover, slope correction, maintaining institutional controls indefinitely, and maintaining and monitoring the soil cover indefinitely. The goal of the limited action was to continue preventing contact with Pad A waste under the soil cover. Remediation activities were classified into two components: (1) recontouring the Pad A soil cover and (2) installing environmental monitoring equipment (Parsons 1995).

The waste pile was covered with a soil layer 0.9 to 1.8 m (3 to 6 ft) thick and was completed at the end of the 1994 field season. In November 1994, the area was seeded with crested wheatgrass to minimize soil erosion, and in February 1995, the southern face was covered with rock armor. Monitoring equipment installed during the Pad A limited action included one horizontal and five vertical boreholes for lysimeters and one horizontal and several vertical neutron access tubes. The horizontal neutron access tube did not provide useful data, and the horizontal lysimeter did not work correctly. Use of the vertical neutron access tubes was discontinued in 1996. Vertical lysimeters, however, are monitored routinely. Monitoring data were used to assess potential migration of moisture and contamination through Pad A to the subsurface.

In 1997, EPA completed the Two-Year Review of Operable Unit 7-12 (Wilkening 1997), which was reviewed by DEQ (Koch 1997). Though DEQ certified that the limited action remedy for Pad A was protective of human health and the environment, subsidence of the soil cover, frequency of inspections, and the inability to establish adequate grass cover were identified as issues.

In 2003, EPA completed the Five-Year Review for Operable Unit 7-12 (Poeton 2003), which was reviewed by DEQ. The EPA determined that the remedy prescribed for Pad A was protective of human health and the environment. Data indicated that the cover was protective, ongoing maintenance and institutional controls precluded prolonged direct contact with Pad A contaminants, and the remedy was functioning as required. Continued monitoring was recommended. The continued lack of vegetation in some areas was an issue of concern.

The Operations and Maintenance Plan for Pad A was updated in 2005 (Flynn 2005). The plan specifies continued quarterly inspections and corrective maintenance of the soil cover and rock armor. However, annual sampling of Pad A lysimeter wells was discontinued under Operable Unit 7-12 and incorporated into overall Waste Area Group 7 monitoring under Operable Unit 7-13/14.

3.2.13 Operable Unit 7-13, Transuranic Pits and Trenches Remedial Investigation and Feasibility Study

Preliminary Scoping Risk Assessments (Loehr et al. 1994; Burns et al. 1994), in conjunction with information from assessments of the other operable units in Waste Area Group 7, revealed the implausibility of evaluating risk for the SDA solely on the basis of the exposure pathway or segregated

source terms. Based on the information, the regulators determined that the TRU pits and trenches should not be assessed independently, but should be combined with the Operable Unit 7-14 comprehensive RI/FS into one all-encompassing risk assessment. Therefore, the TRU pits and trenches operable unit (i.e., Operable Unit 7-13) was combined with Operable Unit 7-14, becoming the Operable Unit 7-13/14 comprehensive RI/FS for Waste Area Group 7 (Huntley and Burns 1995).

3.2.14 Operable Unit 7-13/14, Comprehensive Remedial Investigation and Feasibility Study

The TRU pits and trenches, Operable Unit 7-13, and the Waste Area Group 7 comprehensive RI/FS, Operable Unit 7-14, were combined into the Operable Unit 7-13/14 comprehensive RI/FS. The comprehensive RI/FS was subdivided into two primary reports under the FFA/CO, an RI/BRA and a feasibility study, in accordance with the Operable Unit 7-10 dispute resolution (DOE 2002). The Operable Unit 7-13/14 comprehensive RI/BRA, which constitutes the remedial investigation part of the RI/FS, comprises this report. The feasibility study to evaluate remedial alternatives is being prepared as a separate, companion report.

3.2.15 Active Low-Level Waste Disposal Operations

This Operable Unit 7-13/14 comprehensive RI/BRA includes ongoing disposals in the active LLW Pit, comprising Pits 17 through 20 in the SDA (see Figure 3-25). The active LLW Disposal Facility is operated under a Disposal Authorization (Frei 2000) granted by DOE Headquarters. The Disposal Authorization includes requirements for maintenance of the Performance Assessment (Case et al. 2000) and Composite Analysis (McCarthy et al. 2000) that were conducted to demonstrate compliance with DOE O 435.1, "Radioactive Waste Management," and to develop radionuclide inventory and concentration thresholds for the waste acceptance criteria. Annual reporting of disposal facility operations and details about activities associated with periodic updates (i.e., maintenance) of the Performance Assessment (Case et al. 2000) and Composite Analysis (McCarthy et al. 2000) also are required. Maintenance includes annual reporting and a variety of monitoring, document preparation, and research activities to confirm conservatism of modeling results.

A concerted effort has been made to improve coordination between LLW disposal and remediation and closure of the SDA under CERCLA. This improved coordination includes:

- Sharing monitoring work and reporting
- Using the same staff for modeling in support of the two projects
- Coordinating operations associated with both projects to minimize impacts
- Reviewing project reports and plans for both projects (Seitz and Holdren 2005).

Predecisional drafts of recent revisions to the Performance Assessment (DOE-ID 2005c) and Composite Analysis (DOE-ID 2005d) are available. To the extent possible, modeling to revise the Performance Assessment and Composite Analysis is being coordinated with modeling for the RI/BRA. In many cases, the same models and results are used, while in other cases, the Performance Assessment and Composite Analysis use somewhat simplified model calibrations to facilitate detailed sensitivity and uncertainty analyses. Operational issues also are being coordinated to minimize impacts of disposal operations on remediation efforts and vice versa.



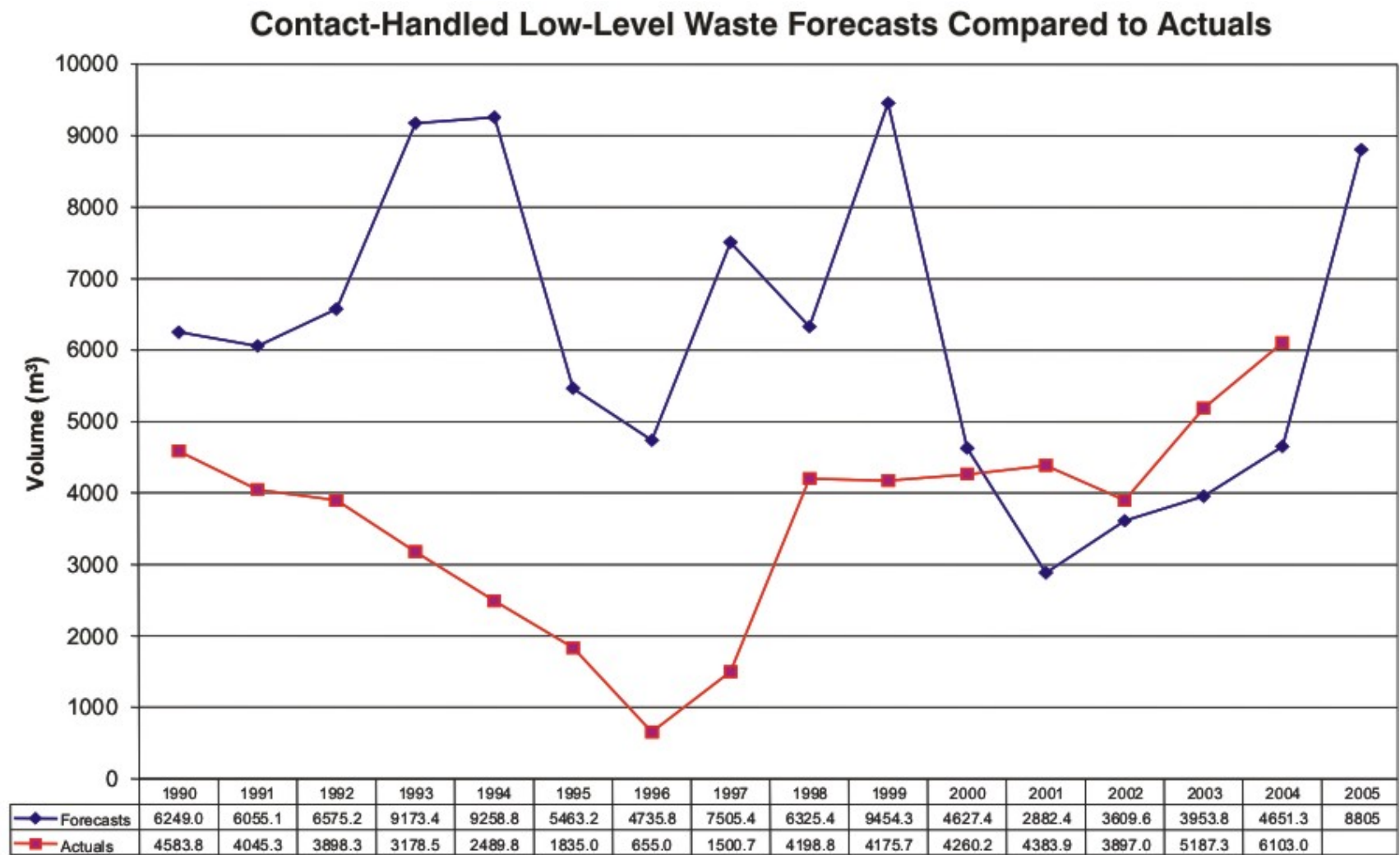
Figure 3-25. Active Low-Level Waste Disposal Facility in contiguous Pits 17 through 20 (top is north).

Disposal operations are planned to continue until the year 2008 for contact-handled LLW and until the year 2009 for remote-handled LLW waste (DOE 2002); however, the end time of disposal operations could change. This RI/BRA addresses actual waste placed in the active LLW Pit through 2003, as well as projected radionuclide inventories from 2004 until the proposed closure date of 2009. For modeling purposes, the entire inventory of the LLW Pit (i.e., actual plus projected) is assumed to be disposed of in 2000. Projections were adjusted to account for inventories in specific waste streams planned for disposal before the closure date. Upper-bound projections also were developed to represent the potential for larger inventories to be disposed of. These are not true upper-bound inventories, but are intended to represent the possibility that larger inventories for some radionuclides may be disposed of. Figures 3-26 and 3-27 illustrate actual and forecasted disposal volumes for the active LLW Disposal Facility from the most recent Annual Review (Parsons, Seitz, and Keck 2005).

Performance assessment and composite analysis maintenance includes the annual reporting mentioned previously and also includes a variety of monitoring, document preparation, and research activities to confirm conservatism of modeling results. A Maintenance Plan (Shuman 2000) was prepared and submitted to DOE Headquarters to document the activities necessary to maintain the Disposal Authorization (Frei 2000). Examples of activities conducted from the Maintenance Plan are described in the following paragraph.

Monitoring of tritium and C-14 in the vadose zone has been conducted where beryllium reflectors were buried, and additional ports are being installed to observe transport in and immediately below waste in the active disposal pits. Monitoring results obtained by the operations and Waste Area Group 7 programs are reported jointly on an annual basis (for an example of a joint annual report, see Koeppen et al. 2005). A subsidence analysis was prepared to provide perspective on the amount of past subsidence and to provide some indication of the potential for future subsidence (Keck and Seitz 2002). The conclusion of the analysis was that final closure plans should account for the possibility of future subsidence. An options analysis, as requested by the Low-Level Waste Facility Federal Review Group, was prepared to discuss the conservatism of assumptions about C-14 migration. The Options Analysis (Seitz 2002) concluded that planned research on C-14 migration and metal corrosion in the near-surface environment was expected to be sufficient to demonstrate conservatism of models used to produce updates for the Performance Assessment and Composite Analysis.

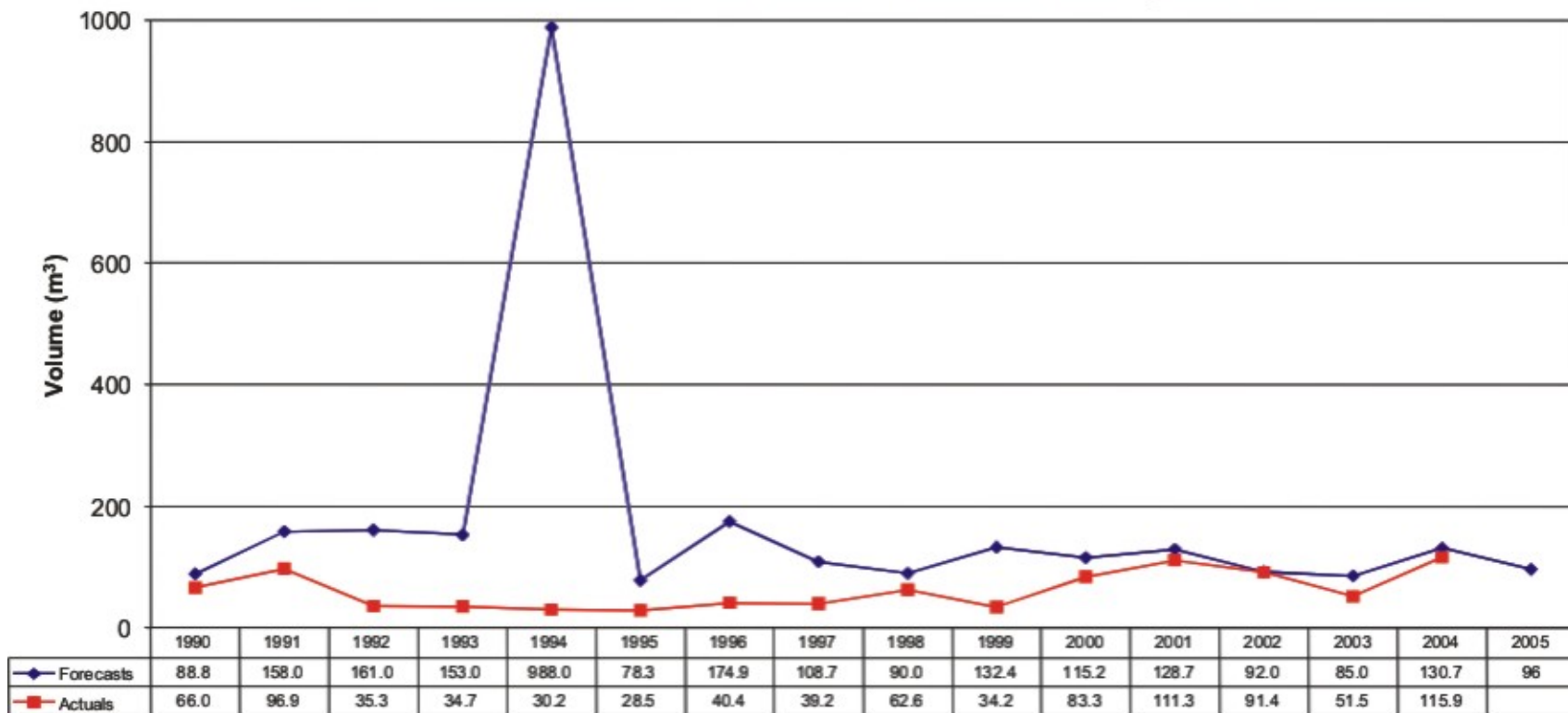
The need for research on corrosion in the near-surface environment and also on C-14 migration in the water and gas phase in the vadose zone was identified by the Low-Level Waste Facility Federal Review Group, and specific activities were outlined in the Maintenance Plan (Shuman 2000). The purpose of the research was to provide additional confirmation of the conservatism of assumptions made in the Performance Assessment and Composite Analysis. Corrosion research results to date (Adler Flitton et al. 2004) confirm conservatism of corrosion rates assumed for the Performance Assessment and Composite Analysis. Likewise, mesoscale column testing of C-14 migration confirms that a large proportion of C-14 would be lost to the atmosphere (Fox et al. 2004), which illustrates that the assumption that all C-14 migrates to the aquifer for groundwater dose assessment is very conservative.



G1569-33

Figure 3-26. Contact-handled low-level waste forecasts compared to actual volumes.

Remote-Handled Low-Level Waste Forecasts Compared to Actuals



G1569-34

Figure 3-27. Remote-handled low-level waste forecasts compared to actual volumes.

3.3 Source-Term Assessment

Because of the heterogeneous nature of waste buried in the SDA, sampling is not sufficient to characterize the SDA source term. Therefore, existing disposal records and information about waste-generating processes were used to develop the source-term inventory as described in the following subsections. A combination of techniques was applied (e.g., reviewing shipping and disposal records, assessing waste-generating processes, evaluating available analytical data, computer modeling, conducting personnel interviews, and using conservative assumptions) to account for incomplete information.

3.3.1 Historical Data Task

The Historical Data Task report (INEL 1995a) is a comprehensive inventory of waste buried in the SDA from 1952 through 1983. Inventory information is organized according to waste generator and divided into waste streams for each generator. Waste information available in facility operating records, technical and programmatic reports, shipping records, and databases were included in the inventory. Additional information was obtained by reviewing plant operations that originally generated the waste, interviewing operations personnel, and performing nuclear physics and engineering calculations. The SDA disposal units covered in the Historical Data Task report include pits and trenches containing TRU-contaminated waste, pits and trenches containing non-TRU-contaminated waste, the Acid Pit, and SVRs open from 1952 through 1983. Total best-estimate, upper-bound, and lower-bound inventory quantities were estimated for each contaminant, covering all waste streams from all generators from 1952 to 1983. Development of inventory estimates is described in detail in the Historical Data Task report.

3.3.2 Recent and Projected Data Task

The Recent and Projected Data Task report (INEL 1995b) is a comprehensive inventory of waste buried from 1984 to 1993 and disposal estimates projected through 2003. Development of inventory estimates is described in detail in the Recent and Projected Data Task report.

Projections for 1994 through 1999 were replaced with actual data in the Supplement to the Recent and Projected Data Task report (Little et al. 2001). In most cases, scaling factors were applied to develop inventories for radionuclides not typically reported on waste disposal forms but expected in waste streams generated by specific processes. Modified actual disposal data replaced projected disposal data for 1994 through 1999. Details about developing inventories included in these disposals are presented in the Supplement to the Recent and Projected Data Task report.

3.3.3 Contaminant Inventory Database for Risk Assessment

Together, the Historical Data Task and Recent and Projected Data Task reports and their revisions describe the SDA source term. All inventory data for all SDA pits, trenches, and soil vaults; Acid Pit; and Pad A were captured electronically in the Contaminant Inventory Database for Risk Assessment. Disposal years for the waste range from 1952 through 1999. Information presented in the Contaminant Inventory Database for Risk Assessment includes types of buried contaminants, amounts of individual contaminants contained in each waste stream, calendar years of waste stream disposal, originator of each waste stream, and contaminant physical and chemical forms. A major limitation of the Historical Data Task and Recent and Projected Data Task reports and, consequently, the Contaminant Inventory Database for Risk Assessment, was a lack of complete disposal information, especially for disposals that occurred during the first two decades of RWMC operations. Historical shipping records sometimes omitted which pits or

trenches received waste, and volumes either were missing from shipping manifests or were estimated based on shipment weight rather than waste stream volume.

The Contaminant Inventory Database for Risk Assessment was used as a basis for the IRA (Becker et al. 1998) and the ABRA (Holdren et al. 2002). Several probable errors in the database were identified, and estimated adjustments were adopted in one or both of those two risk analyses to address the following:

- Revisions to VOC inventories associated with Rocky Flats Plant Series 743 sludge (e.g., carbon tetrachloride, methylene chloride, tetrachloroethylene, and trichloroethylene)
- Duplication of data and incomplete data in RTC inventory estimates
- Corrections to include a more complete set of radioisotopes contained in INL reactor operations waste (e.g., for NRF and Materials and Fuels Complex).

3.3.4 WasteOScope

WasteOScope is a customization of the ArcView Geographic Information System software package. WasteOScope provided a means to merge existing physical spatial data or historical disposal data at RWMC and visualize information on a computer screen or printed graphics (White and Tedrow 2002). The user was able to query, explore, analyze, and then visualize a wide range of waste characterization and inventory data (Potelunas, White, and Tedrow 2002).

Originally, WasteOScope was developed to compare historical disposal data consisting of manifest shipping information from waste generators and trailer load lists received at RWMC with known burial location data. Waste generator data include type of waste container, number of waste containers, type of waste, limited radiological information (e.g., exposure rate), and origin. Waste generators include INL Site facilities (e.g., RTC, INTEC, Test Area North, NRF, and Materials and Fuels Complex), and off-INL Site operations (e.g., Rocky Flats Plant). These data sets then were used to create maps detailing where different waste types from different generators were located. Additional information (e.g., waste container and waste volume) also has been added. A major limitation of WasteOScope was the lack of shipment-level source-term data.

3.3.5 Waste Information and Location Database

The Waste Information and Location Database (McKenzie et al. 2005) is the most recent development in the evolution of databases to store buried waste information associated with the SDA. Predecessor databases did not correlate source-term data to disposal locations effectively. For example, before the Waste Information and Location Database, mapping source-term data to SDA disposal locations involved an arduous and mostly manual process that was inherently error-prone. Source-term data were compiled in an external spreadsheet, imported into ArcView software, and then correlated to WasteOScope disposal locations using associated waste streams or waste types. This process was employed for all contaminants of concern and was reexecuted every time source-term data were updated and mapped. As a result of these limitations, the Waste Information and Location Database was developed.

The Waste Information and Location Database succinctly correlates SDA source-term data to individual disposal locations, thereby eliminating the manual process of mapping source-term data to disposal locations. Both source-term data and location data were migrated to the Waste Information and Location Database, and the Contaminant Inventory Database for Risk Assessment and WasteOScope

have been retired. The Waste Information and Location Database is now the recognized data source for the SDA source-term inventory and associated information (i.e., disposal location, volume, weight, and container count) for pre-June 1997 disposals. The Waste Information and Location Database data set is being validated and verified against original shipping documents, SDA operational records, and predecessor databases.

3.3.6 Inventory Updates

Anomalies revealed by attempts to calibrate source-release and fate and transport models, discovery of additional records, and expanded information about waste-generating processes prompted additional verification of inventories sent to the SDA. This verification focused on contaminants of potential concern identified in the IRA (Becker et al. 1998) and ABRA (Holdren et al. 2002). Additional detailed reviews were completed for several waste generators. Supporting documents were developed to provide a basis for revised inventories that were ultimately incorporated into the Waste Information and Location Database (see Section 3.3.5) and addressed in this RI/BRA. Inventory reviews focused on actinides and VOCs in waste received from Rocky Flats Plant and on fission- and activation-product radionuclides from primary INL Site facilities.

Confidence in inventory data has substantially improved. Reviews found few significant changes to inventories reported in semiannual inventory reports (INEL 1995a; INEL 1995b). Most notable are modifications to carbon tetrachloride from Rocky Flats Plant and C-14 from RTC (formerly called Test Reactor Area). In general, however, most are not substantial. McKenzie et al. (2005) provides a complete summary of inventory adjustments. Completed work includes validating radionuclide inventories for Test Area North (Studley et al. 2004), INTEC (Vail, Carboneau, and Longhurst 2004), Argonne National Laboratory-West (Carboneau and Vail 2004), RTC activation products (Logan 1999) and additional RTC waste streams (McKenzie et al. 2005), NRF (Giles, Holdren, and Lengyel 2005), Rocky Flats Plant VOCs (Miller and Varvel 2005; Varvel 2006), and Rocky Flats Plant actinides (Blackwood and Hoffman 2004; McKenzie et al. 2005).

3.4 Contaminant Screening for the Baseline Risk Assessment

Contaminant screening is an iterative process that has been performed to focus the Operable Unit 7-13/14 comprehensive RI/FS on contaminants with the greatest potential for causing adverse human health or environmental effects. Initially, more than 200 chemical and radioactive contaminants were evaluated. Through iterative risk assessment and contaminant screening, the number of contaminants of potential concern has been significantly reduced. Analysis of the nature and extent of contamination discussed in Section 4 and modeling presented in Section 5 are based primarily on final lists of contaminants of potential concern. Several additional contaminants (e.g., chromium and tritium) are addressed in Sections 4 or 5 to assess site characteristics and model performance. Human health and ecological contaminant screening supporting the risk assessment in Section 6 are summarized in the following subsections.

3.4.1 Human Health Contaminant Screening

Contaminant screening is the process of eliminating from analysis those contaminants that pose no threat to human health and the environment. Conservative assumptions are used in screening to ensure that no contaminant is eliminated that could pose an unacceptable health risk. Several screening and assessment iterations have been completed over the last 10 years for Operable Unit 7-13/14. Each iteration has incorporated improvements and refinements to inventory estimates, modeling, and risk assessment, leading to the final list of contaminants of potential concern that is quantitatively evaluated in this RI/BRA. Discussions that follow summarize the primary iterations of contaminant screening

associated with Preliminary Scoping Risk Assessments (Loehr et al. 1994; Burns et al. 1994), the original Work Plan (Becker et al. 1996), the IRA (Becker et al. 1998), the ABRA (Holdren et al. 2002) and Second Addendum (Holdren and Broomfield 2004), and this RI/BRA.

3.4.1.1 Preliminary Scoping Risk Assessments. Key human health contaminants for Operable Unit 7-13/14 initially were reported in the Preliminary Scoping Risk Assessments (Loehr et al. 1994; Burns et al. 1994), which identified the potential for unacceptable risk to groundwater from highly mobile and long-lived radionuclides (e.g., C-14, Tc-99, and I-129). Potentially unacceptable risk from biotic intrusion into waste and translocation of contaminants to the surface, resulting in human exposure, was also identified. Strictly speaking, Loehr et al. (1994) and Burns et al. (1994) were not screening assessments because they did not eliminate any contaminants or pathways from further evaluation. However, these analyses are important because they identified potential risk drivers, and the monitoring program for the SDA was modified accordingly.

3.4.1.2 Original Work Plan. Subsequent human health contaminant screening is presented in the Work Plan (Becker et al. 1996, Appendix A). Screening was applied to constituents identified in the SDA source-term inventory (INEL 1995a, 1995b). More than 200 contaminants were evaluated to identify those with the greatest potential for causing adverse human health effects. Radionuclides with a half-life less than 1 year and a total inventory less than 1 Ci were immediately eliminated. The following three screening steps, based on upper-bound inventory estimates, were applied to all other contaminants:

1. The summary of the SDA sampling investigations presented in the Historical Data Task report (INEL 1995a, Appendix A) was used to identify contaminants detected in surface soil, sedimentary interbed material, perched water, or groundwater. All contaminants that had been detected in one or more of these media failed the first screening criterion.
2. The computer code GWSCREEN (Rood 1994) was used to estimate maximum future groundwater concentrations for each contaminant in the Snake River Plain Aquifer beneath the SDA. Conservative assumptions were used in groundwater modeling (e.g., only one sedimentary interbed layer was included in the model, upper-bound inventories were used, and no credit was taken for containers or waste forms). All contaminants with predicted groundwater concentrations exceeding maximum contaminant levels (EPA 1996) failed the second screening criterion.
3. Preliminary risk and hazard quotient values were calculated for each contaminant. These calculations were based on conservative assumptions about future contaminant concentrations and about exposures that might be received by future human receptors. In addition to the conservative groundwater modeling assumptions noted above, all the mass was modeled as available at the surface for exposure via the surface pathways. All contaminants that had a predicted risk greater than $1\text{E-}07$ or a predicted hazard quotient greater than 0.1 failed the third screening criterion.

Contaminants that failed any of the above screening criteria were retained for risk assessment. Preliminary screening based on the above process reduced the list of contaminants of potential concern to 86 constituents (i.e., 42 radioisotopes and 44 nonradionuclides, with uranium included in both categories). This list was the basis for the IRA.

3.4.1.3 Interim Risk Assessment Contaminant Screening. In addition to 86 constituents discussed above, five radionuclides subsequently were reinserted in the list because they were members of relevant decay chains and had half-lives greater than 1 year. Therefore, a total of 91 contaminants of potential concern were evaluated in the IRA, based on upper-bound inventories. Sufficient inventory data and risk assessment parameters were available to quantitatively evaluate 53 contaminants of potential concern. The remaining 38 contaminants of potential concern were evaluated qualitatively.

Contaminants retained for evaluation based on the IRA were those with carcinogenic risk estimates greater than 1E-06, a hazard index greater than 0.5, or for which groundwater ingestion risk curves were 1E-07 and still increasing at the end of 1,000 years. Twenty-five contaminants of potential concern were retained for additional quantitative analysis (i.e., 20 radionuclides and five nonradionuclides). While five uranium radioisotopes were retained for evaluation of carcinogenic risk, evaluation of chemical toxicity was discontinued because the hazard index for uranium in the IRA was estimated to be 0.1.

3.4.1.4 Screening in the Ancillary Basis for Risk Analysis and Second Addendum.

Contaminants identified for further evaluation in the IRA were subsequently evaluated in the ABRA (Holdren et al. 2002). The ABRA assessed the 25 contaminants identified in the IRA using best-estimate inventories. Contaminants retained for evaluation based on the ABRA were those with carcinogenic risk estimates greater than 1E-05 or a hazard index greater than 1 within 1,000 years. In addition, three plutonium isotopes (Pu-238, Pu-239, and Pu-240) were retained as special-case contaminants of concern to acknowledge uncertainties about plutonium mobility in the environment and to reassure stakeholders that risk management decisions for the SDA will be fully protective.

The Second Addendum (Holdren and Broomfield 2004) repeated the screening results produced in the ABRA, with only one deviation. The deviation was for Cl-36. In the ABRA, Cl-36 was eliminated from further analysis, based on a cumulative risk estimate less than 1E-05. However, a subsequent correction to Cl-36 inventory lead to a conclusion that risk could exceed 1E-05. Therefore, Cl-36 was retained for quantified modeling and risk assessment in this RI/BRA.

3.4.1.5 Final Contaminant Screening for this Remedial Investigation and Baseline Risk Assessment. Initially, this RI/BRA focused on the list of contaminants identified in the Second Addendum. As work progressed, several questions resulted in additional contaminant screening to ensure that this RI/BRA provides a reasonably conservative, protective basis for the feasibility study. Subsections that follow summarize additional contaminant screening and conclude with the final list of contaminants addressed in the remainder of this report.

3.4.1.5.1 Biotic Pathway—The IRA and ABRA applied an assumption for biotic modeling that contaminants would not be available for biotic uptake and transport until constituents were released from buried waste. Subsequent review determined that this assumption could artificially reduce inventories available for uptake in the simulations, thus reducing risk estimates for surface pathway exposures. Therefore, biotic-uptake modeling for this RI/BRA was modified to allow all inventories in the source that are released as surface wash to be available for immediate biotic uptake instead of delaying availability until released by leaching. Inventory in activated metal is not available for uptake until the metal corrodes. Section 5 contains details regarding source-release and biotic modeling. The important topic for this discussion is contaminant screening. To assess previous screening in the IRA and ABRA, which was based on the less conservative assumption for biotic uptake, the impact of the revised biotic modeling approach on contaminant screening was evaluated, as summarized below.

Twenty-three contaminants were screened in the IRA:

Acetone	Antimony	Beryllium	Butanone
Cadmium	Chromium	Hydrazine	Lead
Mercury	Nickel	Total uranium	Co-60
Cs-137	Eu-152	Eu-154	H-3
Na-22	Ni-59	Ni-63	Pu-241
Pu-242	Th-228	U-232	

Of these 23 contaminants, this review concludes that eight should remain screened out for the following reasons:

- Acetone and butanone are volatile contaminants; therefore, vapor inhalation is the only potential surface exposure pathway. This pathway was adequately addressed with the OCVZ model.
- Hydrazine has an environmental half-life of 17 days.
- Total uranium is appropriately assessed by evaluating individual isotopes.
- Co-60 has a short half-life (5 years), and the IRA showed that peak modeled risk was in the past.
- Tritium reaches the surface as a vapor. Vapor inhalation is the only potential surface exposure pathway; therefore, the source is beryllium blocks, most of which have been grouted.
- Pu-241 and Pu-242 inventories are converted to daughter products (i.e., Am-241 and U-238, respectively) and quantified indirectly in the RI/BRA.

Lead was assessed using EPA's *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children* (EPA 1994). Based on the updated biotic model, the maximum soil concentration of lead is 39 mg/kg. The corresponding geometric mean blood lead level is 1.95 µg/dL, which is well below the 10-µg/dL level of concern set by EPA. Therefore, lead also should remain screened out.

Risk estimates were developed for the remaining 13 contaminants by using current assumptions on contaminant availability and running the biotic model with current best-estimate inventories. Table 3-21 summarizes the results.

Table 3-21. Additional screening for surface exposure contaminants.

Contaminant	Peak Risk	Peak Hazard Index
Cs-137	1.63E-01	NA
Eu-152	3.30E-10	NA
Eu-154	6.96E-08	NA
Na-22	1.62E-11	NA
Ni-59	2.03E-07	NA
Ni-63	8.46E-07	NA
Th-228	1.11E-05	NA
U-232	4.49E-08	NA
Antimony	NA	1.73E-09
Beryllium	1.74E-08	4.32E-03
Cadmium	7.20E-12	7.39E-06
Mercury	NA	9.81E-05
Nickel	NA	3.82E-08
Contaminant retained for the remedial investigation and baseline risk assessment		

Though the revised methodology increases risk from surface pathway exposures by nearly two orders of magnitude, only two additional contaminants of potential concern are identified: Cs-137 and Th-228. Risk greater than 1E-05 was identified for Cs-137 and Th-228; therefore, these two isotopes are identified as contaminants of potential concern for the RI/BRA. Risk from Th-228 is attributable to inventory produced by the decay of U-232 and Th-232.

3.4.1.5.2 Fission Products—As a consequence of review of contaminant screening, all isotopes that could be a part of mixed-fission-product waste streams were reevaluated. The reevaluation found that Se-79 was missing from previous screening, though Se-79 should be present in mixed-fission-product waste streams in quantities roughly equivalent to those for I-129. Therefore, the entire screening of mixed-fission-product isotopes was reviewed.

A list of 197 possible isotopes was extracted from reactor simulation results used to develop inventory estimates for the Waste Information and Location Database (McKenzie et al. 2005). The list was reduced to 81 isotopes by eliminating those with a half-life less than 1 year, as was done in the Work Plan (Becker et al. 1996). Of the 81 remaining isotopes, 46 already have been assessed as part of the original screening in the Work Plan, leaving 35 isotopes to be addressed. Six of the 35 remaining isotopes do not have EPA slope factors; these six isotopes are assumed to be very rare and to not pose significant risk to human health or the environment.

For the remaining 29 isotopes, an upper-bound inventory was developed based on simulations. A screening-level assessment was developed for surface exposure pathways by assigning the entire inventory the top 30 cm (1 ft) of surface soil, decayed 100 years to account for institutional control, and used as input to soil ingestion, dust inhalation, and external exposure pathways for a hypothetical future residential scenario. To assess groundwater pathways, the entire inventory was input into GWSCREEN (Rood 1994), and screening-level risk estimates were developed for the groundwater ingestion pathway. Table 3-22 summarizes the results.

Table 3-22. Screening-level risk estimates for mixed-fission-product isotopes.

Radionuclide	Soil Ingestion Risk	Inhalation Risk	External Exposure Risk	Groundwater Ingestion Risk
Am-242m	1.63E-05	3.02E-06	3.03E-06	1.32E-23
Bi-210m	2.89E-14	3.58E-15	4.60E-12	1.37E-14
Cd-113m	1.83E-06	7.13E-09	3.63E-07	0.00E+00
Cf-249	1.10E-10	2.26E-11	1.36E-08	1.58E-22
Cf-250	7.40E-13	1.63E-13	4.08E-15	0.00E+00
Cf-251	4.30E-12	8.40E-13	1.38E-10	2.28E-19
Cm-243	6.50E-06	1.31E-06	3.03E-04	0.00E+00
Cm-245	2.11E-06	4.10E-07	5.24E-05	1.27E-09
Cm-246	7.60E-07	1.52E-07	3.73E-09	3.51E-11
Cm-247	3.62E-12	6.57E-13	5.12E-10	5.32E-13
Cm-248	NA	NA	1.10E-13	NA
Cs-135	5.72E-07	2.27E-10	4.29E-08	4.33E-08
Ho-166m	1.93E-09	4.36E-11	1.61E-05	6.55E-21
In-115	9.72E-08	1.03E-09	1.02E-08	4.70E-09
Kr-81	NA	NA	1.12E-11	NA
La-138	8.33E-16	4.42E-17	1.31E-11	6.46E-17
Np-236a	1.86E-11	1.09E-12	5.40E-09	3.96E-11
Pd-107	6.78E-09	2.42E-11	0.00E+00	4.87E-09
Pu-236	4.30E-17	8.63E-18	6.70E-19	0.00E+00
Rb-87	1.71E-10	4.49E-14	2.84E-11	1.49E-10
Rh-102	4.70E-17	2.52E-19	6.10E-13	0.00E+00
Se-79	3.28E-06	1.05E-09	5.15E-08	5.65E-06

Table 3-22. (continued).

Radionuclide	Soil Ingestion Risk	Inhalation Risk	External Exposure Risk	Groundwater Ingestion Risk
Sm-146	1.68E-12	2.42E-13	0.00E+00	1.59E-13
Sm-151	1.46E-04	6.88E-07	7.55E-07	0.00E+00
Sn-121m	8.27E-08	2.93E-10	2.51E-07	0.00E+00
Sn-126	1.34E-05	2.89E-08	4.31E-04	1.47E-06
Tc-98	1.64E-11	4.12E-14	1.31E-07	2.98E-09
Te-123	7.60E-19	4.30E-22	6.99E-18	1.93E-19
Tm-171	1.38E-28	3.48E-31	1.08E-27	0.00E+00
Screening-level risk greater than 1E-05				

Surface exposure pathways associated with screening-level risk estimates in Table 3-22 are greater than 1E-05 for six isotopes. Therefore, the current, more conservative biotic-uptake model (see the preceding subsection) was run for each of these six isotopes. Refined risk estimates are presented in Table 3-23. All of the risk estimates based on updated biotic modeling are less than 1E-05. Therefore, all 29 of the mixed-fission-product isotopes screen, and no additional contaminants of potential concern are identified for quantitative analysis in the RI/BRA.

Table 3-23. Surface pathway risks for mixed-fission-product isotopes.

Radionuclide	Peak Surface Pathway Risk
Am-242m	3.69E-07
Cm-243	2.02E-09
Cm-245	1.58E-07
Ho-166m	3.12E-08
Sm-151	2.53E-08
Sn-126	1.25E-06

3.4.1.5.3 **Acceptable Knowledge**—After

determining contaminants of potential concern for the RI/BRA (Holdren and Broomfield 2004) and late while preparing this RI/BRA, additional information was developed in support of the Accelerated Retrieval Project in Pit 4 (see Section 3.1.5.7). A list of chemical constituents was compiled to develop a hazardous waste determination for waste to be disposed of at WIPP. The Acceptable Knowledge Report for Pit 4 Retrieval (CCP 2005) and its associated chemical constituents list are living documents, and will be revised if additional retrieval actions are initiated. The ongoing revision of the Acceptable Knowledge Report for Pit 4 Retrieval identifies approximately 500 chemical constituents, most occurring in trace amounts. Many of the

constituents are components of commercially available formulations. To ensure that previous contaminant screening has not overlooked chemical constituents identified during the discovery process, a professional judgment analysis—consistent with those used for previous iterations of contaminant screening—identified one additional contaminant of potential concern: 1,4-dioxane.

3.4.1.5.4 Review of Qualitatively Evaluated Contaminants—Twenty-nine nonradioactive contaminants and nine radioactive contaminants were evaluated qualitatively in the IRA (Section 6.5.3.1.4 of Becker et al. 1998) because data were not sufficient to develop quantified risk estimates. Either inventory data or toxicity values were not available. Though only nine of the nonradioactive contaminants and none of the radioactive contaminants were retained in the IRA for further evaluation, all of them are reviewed in Table 3-24 to ensure completeness.

Table 3-24. Review of qualitatively evaluated contaminants.

Contaminant	Interim Risk Assessment	Screening for this RI/BRA
Anthracene	Inhalation RfD under review	Eliminated—no change in data; low qualitative risk ^a
Asbestos	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Benzene	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
1,4-Bis(5-phenyloxazol-2-yl) benzene	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Chloroform	Unknown disposal quantity—retained to assess chemical degradation	Eliminated—assumed to be subsumed by carbon tetrachloride, its more toxic parent compound ^a
Copper	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Dibutylethylcarbutol	Unknown disposal quantity and no toxicity data	Eliminated—no change in data; qualitative risk could not be evaluated ^a
Diisopropylfluorophosphate	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Diphenyl	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Ethyl alcohol	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Fluoride	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Magnesium	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Manganese	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Methyl alcohol (methanol)	Inhalation RfD under review	Eliminated—RfD still not available; RfC available but not applicable to dissolved phase; low qualitative risk ^a
Methyl isobutyl ketone	Oral and inhalation RfD under review	Eliminated—RfD still not available; RfC available but not applicable to dissolved phase; low qualitative risk ^a
3-Methyl-cholanthrene	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Nitrocellulose	Unknown disposal quantity—retained in the IRA because of hypothesis that an unknown quantity could form by reaction of nitric acid with cellulose waste	Eliminated—Einerson and Thomas (1999) determined that reagents and conditions used in Rocky Flats Plant processes were not conducive to formation of nitrocellulose
Organic acids	Unknown disposal quantity—originally retained in the IRA to assess effects on actinide mobility	Eliminated—not a human health toxin; actinide mobility is addressed directly (see Section 5.2.3.6)

Table 3-24. (continued).

Contaminant	Interim Risk Assessment	Screening for this RI/BRA
Organophosphates	Unknown disposal quantity	Eliminated—no change in data; qualitative risk could not be evaluated ^a
Phosphate	Unknown disposal quantity	Eliminated—no change in data; common in fertilizers ^a
Polychlorinated biphenyl	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Sodium cyanide	Unknown disposal quantity	Eliminated—no change in data; low qualitative risk ^a
Sulfate	Unknown disposal quantity	Eliminated—no change in data; common in fertilizers ^a
Terphenyl	No toxicity data	Eliminated—no change in data; low qualitative risk ^a
Toluene	Unknown disposal quantity—originally retained pending inventory revisions for Rocky Flats Plant volatile organic compounds	Eliminated—no change in data; inventory revisions for volatile organic compounds did not identify toluene in process sludge (Miller and Varvel 2005; Varvel 2006), and toluene was not identified in significant quantities in Rocky Flats Plant operations (Abbott et al. 2005)
1,1,1-Trichloroethane	No toxicity data	Eliminated—no change in toxicity data; inventory was revised downward (Varvel 2006)
Trichloroethylene	No toxicity data	Retained—though inventory was revised downward (Varvel 2006), toxicity data now available from the California Office of Environmental Hazard Health Assessment (OEHHA 2003); based on scaling against carbon tetrachloride, trichloroethylene risk could exceed 1E-05
Versenes ^b	Unknown disposal quantity—originally retained in the IRA to assess effects on actinide mobility	Eliminated—not a human health toxin; actinide mobility is addressed directly (see Section 5.2.3.6)
Xylene	No toxicity data	Eliminated—toxicity data now available; based on scaling against carbon tetrachloride, the estimated xylene hazard index is much less than 1
Be-10	No toxicity data	Eliminated—toxicity data now available; maximum screening risk is 6E-06 for soil ingestion
Cf-252	No toxicity data	Eliminated—toxicity data now available; maximum screening risk is 2E-20 for external exposure
Hf-175	No toxicity data	Eliminated—toxicity data now available; half-life less than 1 year
Hf-181	No toxicity data	Eliminated—toxicity data now available; half-life less than 1 year
Ir-192	No toxicity data	Eliminated—toxicity data now available; half-life less than 1 year

Table 3-24. (continued).

Contaminant	Interim Risk Assessment	Screening for this RI/BRA
Mn-53	No toxicity data	Eliminated—toxicity data now available; maximum screening risk 6E-10 for soil ingestion
Sn-117m	No toxicity data	Eliminated—toxicity data now available; half-life less than 1 year
Sn-119m	No toxicity data	Eliminated—toxicity data now available; half-life less than 1 year
Yb-164	No toxicity data	Eliminated—no change in data; half-life less than 1 year
a. See Section 6.5.3.1.1 of Becker et al. (1998). b. Versene is assumed to be ethylenediaminetetraacetic acid (EDTA). IRA = Interim Risk Assessment (Becker et al. 1998) RfC = reference concentration RfD = reference dose RI/BRA = remedial investigation and baseline risk assessment		
Retained in the IRA		
Retained for this RI/BRA		

The IRA retained organic acids and Versenes (e.g., ethylenediaminetetraacetic acid [EDTA]) for additional evaluation, based on uncertainty relating to the potential effect of EDTA on mobility of actinides, including plutonium, in the subsurface. While man-made (Means 1978) and naturally occurring (McCarthy, Sanford, and Stafford 1998) chelators have been implicated in mobilization of radioactive contaminants, environmental monitoring for actinides in the vadose zone beneath the SDA (see Section 4) does not support the hypothesis that episodic migration of actinide complexes has occurred (see Section 5.2.4.3.5 for known surface water infiltration events). Because they are not identified as human toxins for chronic-exposure scenarios, both organic acids and EDTA were eliminated from further evaluation. Section 3.7 provides additional discussion on the potential for facilitated transport of plutonium. Risk associated with potential migration of a mobile plutonium fraction was evaluated, as described in Section 5.2.3.6.

Toxicity data have not been developed by EPA for any of the chemicals identified in Table 3-24; however, toxicity values for trichloroethylene are available from the California Office of Environmental Health Hazard Assessment (OEHHA 2003). Carbon tetrachloride risk was scaled to determine the potential risk from trichloroethylene. The scaled risk is greater than 1E-05; therefore, risk for trichloroethylene should be quantified.

The EPA has developed slope factors for seven of the eight isotopes in Table 3-24. Upper-bound inventories were evaluated for these seven radionuclides using the risk calculation methodology identified in the Work Plan and highlighted in Section 3.4.1.2. None of the isotopes had a risk estimate greater than 1E-05 for any pathway and are screened from further evaluation.

Though risk computed for Be-10 approaches 1E-05, eliminating it is still appropriate because the screening calculation does not account for factors that would reduce the risk estimate: (1) most of the Be-10 is in beryllium blocks (activated metal) that would release contamination slowly by corrosion and (2) most of the beryllium blocks have been grouted to reduce corrosion (see Section 3.1.6). As noted in the IRA (see Section 6.5.3.1.1.30 of Becker et al. 1998), the original Be-10 inventory reported for waste stream PER-ORM-1H (e.g., paper, cloth, and wood) is not credible; therefore, Be-10 inventory used for this screening did not include PER-ORM-1H.

3.4.1.5.5 Final List of Contaminants of Potential Concern for Quantitative Evaluation in this Remedial Investigation and Baseline Risk Assessment—In total, 23 radionuclide and six nonradionuclide contaminants of potential concern are retained for quantitative evaluation in this RI/BRA. Contaminants modeled in Section 5 and evaluated in Section 6 for human health risk are:

- Radioisotopes—Ac-227, Am-241, C-14, Cl-36, Cs-137, I-129, Nb-94, Np-237, Pa-231, Pb-210, Pu-238, Pu-239, Pu-240, Ra-226, Ra-228, Sr-90, Tc-99, Th-228, U-233, U-234, U-235, U-236, and U-238
- Volatile organic compounds—carbon tetrachloride, 1,4-dioxane, methylene chloride, tetrachloroethylene, and trichloroethylene
- Chemicals—nitrate.

Table 3-25 summarizes progression of contaminant screening for those contaminants initially retained in the original Work Plan that could be quantitatively evaluated, ending with contaminants retained for this RI/BRA. Contaminants that were retained and evaluated qualitatively are provided in Table 3-24.

Table 3-25. Iterative screening of quantitatively evaluated contaminants.

Contaminant	Retained in the Original Work Plan ^{a,b}	IRA Screening	ABRA and Second Addendum Screening	Screening for this RI/BRA
Ac-227	No			
Am-241	Yes			
Am-243	Yes			
C-14	Yes			
Cl-36	Yes			
Cm-244	Yes			
Co-60	Yes			
Cs-137	Yes			
Eu-152	Yes			
Eu-154	Yes			
H-3	Yes			
I-129	Yes			
Na-22	Yes			
Nb-94	Yes			
Ni-59	Yes			
Ni-63	Yes			
Np-237	Yes			
Pa-231	No			
Pb-210	No			
Pu-238	Yes			
Pu-239	Yes			
Pu-240	Yes			
Pu-241	Yes		Added to parent	Added to parent

Table 3-25. (continued).

Contaminant	Retained in the Original Work Plan ^{a,b}	IRA Screening	ABRA and Second Addendum Screening	Screening for this RI/BRA
Pu-242	Yes		Added to parent	Added to parent
Ra-226	Yes			
Ra-228	No			
Sr-90	Yes			
Tc-99	Yes			
Th-228	No			
Th-229	Yes			
Th-230	Yes			
Th-232	Yes			
U-232	Yes			
U-233	Yes			
U-234	Yes			
U-235	Yes			
U-236	Yes			
U-238	Yes			
Acetone	Yes			
Antimony	Yes			
Beryllium	Yes			
2-Butanone	Yes			
Cadmium	Yes			
Carbon tetrachloride	Yes			
Chromium	Yes			
1,4-Dioxane	Not evaluated	Not evaluated	Not evaluated	
Hydrazine	Yes			
Lead	Yes			
Mercury	Yes			
Methylene chloride	Yes			
Nickel	Yes			
Nitrate	Yes			
Tetrachloroethylene	Yes			
Trichloroethylene	Yes	Qualitatively retained	Not evaluated	
Total uranium	Yes			

a. The Work Plan (Becker et al. 1996) evaluated 160 radionuclides; 117 (including Ac-227, Pa-231, Pb-210, Ra-228, and Th-228) were eliminated, and 43 were retained. Appendix A of the Work Plan lists the 117 radionuclides that were eliminated.

b. The Work Plan (Becker et al. 1996) evaluated 77 nonradionuclides; 33 were eliminated, and 44 were retained. Appendix A of the Work Plan lists the 33 nonradionuclides that were eliminated.

ABRA = Ancillary Basis for Risk Analysis (Holdren et al. 2002)

IRA = Interim Risk Assessment (Becker et al. 1998)

RI/BRA = remedial investigation and baseline risk assessment (i.e., analysis presented in this report)

IRA based on upper-bound inventories	Retained	Eliminated
ABRA and Second Addendum based on best-estimate inventories	Retained	Eliminated
RI/BRA based on best-estimate inventories	Retained for analysis in this RI/BRA	

3.4.2 Ecological Contaminant Screening

Although previous contaminant screenings have been conducted to identify ecological contaminants of potential concern (Hampton and Becker 2000; Holdren et al. 2002), all radiological and nonradiological contaminants contained in the Waste Inventory and Location Database were reevaluated to (1) incorporate final changes to inventory amounts, (2) more accurately represent the size of the SDA in the calculation of initial screening concentrations, and (3) account for recent changes to the biotic modeling methodology (see Section 5.5).

3.4.2.1 Radionuclide Ecological Contaminants of Potential Concern. Rescreening for radiological contaminants of potential concern consisted of two steps.

In the first step, inventories for radionuclide contaminants of potential concern with half-lives under 5 years are calculated to have decayed before 2005. Consequently, 125 contaminants were eliminated from further evaluation.

In the second step of screening, upper-bound concentrations, based on finalized inventory values, were calculated for the remaining 185 contaminants of potential concern and compared to current ecologically based screening levels (see Table 3-26). An ecologically based screening level is defined as the concentration in soil or other media above which chronic exposure by ecological receptors can be expected to produce adverse effects (Kester, VanHorn, and Hampton 1998). For this screening, the lowest ecologically based screening level across all receptor groups and individuals was used (DOE-ID 1999). For radiological contaminants, the lower between internal and external exposure ecologically based screening levels was used. Parameter values and methods used to develop the most current ecologically based screening levels are documented in detail in the Work Plan for Waste Area Groups 6 and 10 Comprehensive RI/FS (DOE-ID 1999).

As in the preliminary screening (Hampton and Becker 2000), concentrations were derived by distributing upper-bound inventory amounts in a volume of soil equivalent to the combined volume of pits, vaults, and trenches, and spreading it across the SDA. The increase in the size of the SDA from 36 ha (88 acres) to 39 ha (97 acres) when the perimeter fence was reconstructed was not accounted for by Hampton and Becker (2000). In screening for the RI/BRA, upper-bound concentrations were calculated by distributing the inventory amount over a $181 \times 669 \times 2.53$ -m ($594 \times 2,194 \times 8$ -ft) volume of soil with a bulk density of 1.5 g/cm^3 . Incorporating the larger SDA footprint resulted in lower screening concentrations than those calculated by Hampton and Becker (2000).

If the estimated concentration was greater than the ecologically based screening level, the contaminant was identified as an ecological contaminant of potential concern. When calculated concentrations were below the ecologically based screening level, the contaminant was eliminated from further evaluation. One hundred and sixty-nine radiological contaminants of potential concern were eliminated in this step (see Table 3-26). The 16 radiological contaminants of potential concern highlighted in Table 3-26 failed both steps of the screening and were retained for evaluation in the ecological risk assessment (see Section 6.7).

Table 3-26. Comparison of upper-bound radionuclide inventory to minimum ecologically based screening levels.

Contaminant ^a	Half-Life ^b (years)	Upper-Bound Inventory ^c (Ci)	Upper-Bound Concentration (pCi/g)	Minimum Screening Level ^d (pCi/g)
Ac-227	2.18E+01	1.16E-05	1.58E-05	2.04E+05
Ag-108m	1.27E+02	3.28E-01	4.47E-01	1.82E+03
Am-241	4.32E+02	3.06E+05	4.17E+05	1.78E+01
Am-242m ^e	1.41E+02	1.00E-05	1.37E-05	None
Am-243	7.38E+03	1.60E-01	2.17E-01	1.85E+01
Ba-133	1.07E+01	1.37E-02	1.87E-02	7.34E+03
Be-10	1.60E+06	4.39E+02	5.98E+02	9.63E+03
C-14	5.73E+03	1.04E+03	1.42E+03	3.94E+04
Cd-113 ^e	9.3E+15	9.80E-10	1.33E-09	None
Cd-113m ^e	1.36E+01	1.47E-03	2.00E-03	None
Cl-36	3.01E+05	2.05E+00	2.80E+00	7.84E+03
Cm-243 ^e	2.85E+01	3.10E-02	4.23E-02	None
Cm-244	1.81E+01	5.76E+01	7.85E+01	1.68E+01
Cm-245 ^e	8.50E+03	4.95E-03	6.74E-03	None
Cm-246 ^e	4.73E+03	1.66E-02	2.27E-02	None
Cm-247 ^e	1.56E+07	1.82E-07	2.48E-07	None
Cm-248	3.39E+05	4.10E-06	5.59E-06	2.10E+01
Co-60	5.27E+00	7.54E+06	1.03E+07	1.18E+03
Cs-135 ^e	2.30E+06	4.16E-05	5.67E-05	None
Cs-137	3.00E+01	3.12E+05	4.25E+05	4.95E+03
Eu-152	1.33E+01	1.19E+02	1.62E+02	2.18E+03
Eu-154	8.8E+00	2.46E+03	3.36E+03	2.48E+03
Tritium	1.23E+01	3.56E+06	4.85E+06	3.43E+05
I-129	1.57E+07	1.33E+01	1.82E+01	4.76E+04
K-40 ^f	1.28E+09	1.92E+00	2.61E+00	None
Kr-85	1.07E+01	1.50E+01	2.04E+01	3.70E+03
Mn-53	3.70E+06	6.25E-03	8.51E-03	2.25E+06
Mo-93 ^e	3.50E+03	3.43E-03	4.67E-03	None
Nb-93m	1.36E+01	5.09E-02	6.93E-02	1.51E+06
Nb-94	2.03E+04	2.77E+02	3.77E+02	1.87E+03
Ni-59	7.50E+04	1.25E+04	1.71E+04	1.24E+06
Ni-63	9.60E+01	9.89E+05	1.35E+06	1.14E+05
Np-237	2.14E+06	1.99E-01	2.72E-01	1.94E+01
Pa-231	3.28E+04	5.22E-03	7.10E-03	2.37E+01
Pb-210	2.23E+01	5.99E-05	8.15E-05	2.74E+05
Pd-107 ^g	6.50E+06	1.32E-06	1.79E-06	None

Table 3-26. (continued).

Contaminant ^a	Half-Life ^b (years)	Upper-Bound Inventory ^c (Ci)	Upper-Bound Concentration (pCi/g)	Minimum Screening Level ^d (pCi/g)
Pu-238	8.77E+01	2.81E+03	3.82E+03	1.78E+01
Pu-239	2.41E+04	8.88E+04	1.21E+05	1.89E+01
Pu-240	6.54E+03	2.28E+04	3.10E+04	1.89E+01
Pu-241	1.44E+01	5.21E+05	7.10E+05	3.73E+05
Pu-242	3.76E+05	3.08E-02	4.19E-02	2.00E+01
Pu-244	8.26E+07	1.39E-08	1.89E-08	2.12E+01
Ra-226	1.60E+03	8.68E+01	1.18E+02	2.04E+01
Ra-228	5.75E+00	1.09E-05	1.48E-05	1.97E+05
Se-79 ^e	6.50E+04	7.55E-06	1.03E-05	None
Sm-151 ^e	9.00E+01	1.03E-01	1.41E-01	None
Sn-121m ^e	5.50E+01	5.73E-07	7.80E-07	None
Sn-126 ^e	1.00E+05	1.43E-05	1.95E-05	None
Sr-90	2.91E+01	2.43E+05	3.31E+05	3.34E+03
Tc-99	2.13E+05	7.58E+01	1.03E+02	1.60E+04
Th-229	7.34E+03	7.33E-06	9.99E-06	3.60E+01
Th-230	7.70E+04	3.58E-02	4.88E-02	2.09E+01
Th-232	1.41E+10	1.63E+00	2.21E+00	2.43E+01
U-232	7.20E+01	1.36E+01	1.85E+01	1.54E+01
U-233	1.59E+05	2.54E+00	3.46E+00	2.03E+01
U-234	2.45E+05	1.14E+02	1.55E+02	2.05E+01
U-235	7.04E+08	7.83E+00	1.07E+01	2.27E+01
U-236	2.34E+07	2.29E+00	3.12E+00	2.17E+01
U-238	4.47E+09	2.65E+02	3.61E+02	2.32E+01
Zr-93	1.53E+06	6.03E+00	8.22E+00	9.95E+04

a. The contaminants evaluated here represent the full SDA inventory contained in the Waste Inventory and Location Database.

b. Half-life values are compiled from the EPA Health Effects Assessment Summary Tables (EPA 2001) unless otherwise specified.

c. Inventory values contained in the Waste Inventory and Location Database.

d. The minimum ecologically based screening level across receptor groups was selected for both radionuclide and nonradionuclide contaminants. For radionuclide contaminants, the smallest ecologically based screening level between internal or external exposures was selected (DOE-ID 1999).

e. No INL Site ecologically based screening level has been developed for this contaminant. However, upper-bound concentrations for different congeners of the same radionuclide with substantially larger inventories are well below corresponding ecologically based screening levels. Therefore, this contaminant was eliminated from further evaluation.

f. Potassium-40 occurs naturally. Based on previous INL Site screening criteria, a calculated concentration less than 10 times INL Site background (24 pCi/g compared to an upper-bound concentration of 26 pCi/g) (Rood, Harris, and White 1996) permits elimination of this contaminant of potential concern from further analysis.

g. No ecologically based screening level has been developed for this contaminant or its congeners. However, concentrations for other actinides at or above this inventory level, including thorium and uranium, are well below ecologically based screening levels.

EPA = U.S. Environmental Protection Agency

INL = Idaho National Laboratory

SDA = Subsurface Disposal Area

Contaminant concentrations that failed Step 2 of the screening.

3.4.2.2 Nonradionuclide Ecological Contaminants of Potential Concern. Nonradiological contaminants identified as contaminants of potential concern in the preliminary screening by Hampton and Becker (2000) (see Table 3-27) were rescreened for the environmental risk assessment using two steps.

In the first step, upper-bound concentrations were recalculated for all nonradiological contaminants of potential concern using the larger size of the SDA (see Section 3.1.2.1) and minor inventory changes contained in the Waste Inventory and Location Database. In the second step, upper-bound concentrations for the 48 contaminants of potential concern were compared to ecologically based screening levels (see Table 3-27). The suite of nonradionuclide contaminants of potential concern identified in this step differs from the preliminary screening because 1,4-dioxane, chromium, potassium dichromate, and sodium hydroxide were added as contaminants of potential concern, and asbestos, chloroform, copper, ethyl alcohol, hydrazine, magnesium, mercury, sodium cyanide, and toluene were eliminated from further evaluation. The 40 nonradiological contaminants of potential concern highlighted in Table 3-27 were retained for further evaluation in the environmental risk assessment (see Section 6.7).

Table 3-27. Nonradionuclide ecological contaminants of potential concern.

Ecological Contaminant of Potential Concern ^a	Upper-bound Inventory ^b (g)	Calculated Soil Concentration ^c (mg/kg)	Minimum Screening Level ^d (mg/kg)
1,1,2-Trichloro-1,2,2-trifluoroethane	9.69E+06	1.32E+01	None
1,4-Dioxane	6.23E+07	8.48E+01	None
3-Methylcholanthrene	Unknown	Unknown	None
Alcohols	Unknown	Unknown	None
Aluminum nitrate	2.39E+08	3.26E+02	4.87E+01, see total nitrate
Asbestos	4.80E+06	6.54E+00	2.17E+02
Beryllium	2.19E+07	2.98E+01	7.14E-1
Cadmium	2.36E+06	3.22E+00	2.36E-03
Carbon tetrachloride	1.00E+09	1.36E+03	9.71E+00
Chloroform	3.73E+01	5.08E-05	1.54E+01
Chromium	2.32E+06	3.16E+00	1.62E-01
Copper (total) ^e	4.54E+04	6.18E-02	2.11E+00
Dibutylethylcarbutol	Unknown	Unknown	None
Ether	Unknown	Unknown	None
Ethyl alcohol	2.80E+04	3.82E-02	1.59E+00
Hydrazine ^f	2.24E+03	3.05E-03	1.42E-03
Hydrofluoric acid	9.50E+06	1.29E+01	5.26E+00
Lead	8.87E+08	1.21E+03	9.94E-01
Lithium hydride	Unknown	Unknown	None
Lithium oxide	Unknown	Unknown	None
Manganese	Unknown	Unknown	1.05E+01
Magnesium ^g	1.08E+07	1.47E+01	None
Mercury (total) ^{h,i}	1.96E+06	2.67E+00	6.21E-03, ^j 4.18E+00 ^k
Methylene chloride	1.55E+07	2.11E+01	1.00E+00
Nitrate (total) ^l	4.56E+08	6.21E+02	1.84E+01
Nitrobenzene	Unknown	Unknown	1.95E+00

Table 3-27. (continued).

Ecological Contaminant of Potential Concern ^a	Upper-bound Inventory ^b (g)	Calculated Soil Concentration ^c (mg/kg)	Minimum Screening Level ^d (mg/kg)
Nitrocellulose	Unknown	Unknown	None
Nitric acid	6.27E+07	8.54E+01	3.28E+01
Organic acids (ascorbic acid)	Unknown	Unknown	None
Organophosphates (tributylphosphate)	Unknown	Unknown	3.99E+01
Potassium chloride	1.08E+08	1.47E+02	2.10E+01
Potassium dichromate	3.05E+06	4.15E+00	None
Potassium hydroxide	4.30E+07	5.86E+01	1.66E+00
Potassium nitrate	2.44E+09	3.33E+03	5.52E+01
Potassium phosphate	5.44E+07	7.41E+01	1.88E+01
Potassium sulfate	1.08E+08	1.47E+02	3.25E+01
Sodium chloride	2.16E+08	2.94E+02	9.35E+00
Sodium cyanide	1.87E+03	2.55E-03	1.43E-01
Sodium hydroxide	8.40E+07	1.14E+02	6.82E+00
Sodium nitrate	1.49E+09	2.03E+03	None, see total nitrate
Sodium phosphate	1.08E+08	1.47E+02	5.23E+01
Sodium potassium	2.33E+06	3.17E+00	None
Sulfuric acid	1.51E+05	2.05E-01	1.20E-01
Tetrachloroethylene	2.70E+08	3.68E+02	3.33E+00
Toluene	2.59E+05	3.52E-01	6.04E+01
Trichloroethylene	2.41E+08	3.38E+02	1.74E+01
Trimethylpropane-triester	2.48E+08	3.38E+02	1.30E-01
Versenes (ethylenediaminetetraacetic acid)	Unknown	Unknown	None
Xylene	1.02E+06	1.38E+00	2.78E-01

a. The contaminants of potential ecological concern were originally identified in the preliminary screening (Hampton and Becker 2000).

b. Upper-bound inventory quantities are in the Waste Inventory and Location Database.

c. Upper-bound concentrations were calculated by distributing the inventory amount over a soil volume (i.e., $181 \times 669 \times 2.53$ m [$594 \times 2,195 \times 8.3$ ft]) with a bulk density of 1.5 g/cm^3 (Becker et al. 1996). Volume represents an estimate of the combined volumes for Subsurface Disposal Area pits, trenches, and soil vaults.

d. The minimum ecologically based screening level across receptor groups was selected for nonradionuclide contaminants (DOE-ID 1999).

e. Total includes copper and copper nitrate.

f. According to an Agency for Toxic Substances and Disease Registry toxicity profile (<http://www.atsdr.cdc.gov/toxprofiles/tp100-c5.pdf>), hydrazine has a half-life of up to several weeks in the environment, depending on the medium. Therefore, this contaminant was not evaluated further.

g. Magnesium is considered an essential nutrient. Based on prior INL Site screening criteria, concentrations less than the INL Site background (Rood, Harris, and White 1996) are eliminated from further analysis ($1.20\text{E}+04 \text{ mg/kg}$ background, upper-bound concentration of 14.7 mg/kg).

h. Although the upper-bound mercury concentration exceeds the ecologically based screening level for organic mercury, the primary waste containing mercury included inorganic forms mixed with acid. Disposals were mixed with lime and buried in the Acid Pit, which was grouted in 1997 to immobilize the waste (see Section 3.2.2). Therefore, this contaminant was eliminated from further evaluation.

i. Total includes mercury and mercury nitrate monohydrate.

j. The value shown is the ecologically based screening level for organic mercury.

k. The value shown is the ecologically based screening level for inorganic mercury.

l. Total includes aluminum nitrate, ammonia, copper nitrate, mercury nitrate monohydrate, nitric acid, potassium nitrate, sodium nitrate, and uranyl nitrate.

INL = Idaho National Laboratory

Contaminants that failed screening and were retained for environmental risk assessment.

3.5 Geophysical Investigations

3.5.1 Confirmation of Subsurface Disposal Area Disposal Locations

Boundaries for waste burial locations within the SDA were originally marked using metal tags attached to the perimeter fencing (see Section 3.1.2.1). Later, concrete monuments were placed instead. Occasionally, these location monuments were moved during SDA maintenance operations, eventually resulting in significant uncertainty about the position of some burial locations.

Geophysical investigations have confirmed the location of historic pit and trench boundaries within the SDA. Magnetic and electromagnetic properties have been measured near the ground surface in areas where buried waste material was suspected. The presence of buried metal objects, including metal waste containers, is inferred from discontinuities, so-called anomalies (Sheriff 1973), in graphic representations of vertical magnetic field or electromagnetic induction.

Table 3-28 lists 12 surface geophysical studies conducted at the SDA since 1989. These studies range from small-area technology demonstrations to detailed surveys of the entire SDA. Raw data for most recent geophysical surveys are available in electronic format. Electronic data are stored in the Nuclear Logging and Surface Geophysics Database (PLN-1709). Data from some early surveys are available only in summary reports.

Table 3-28. Summary of geophysical surveys of the Subsurface Disposal Area (1989 through 2004).

Performer	Date	Methods	Survey Area	Digital Data
UNC Geotech ^a	1989	Magnetic, electromagnetic, and seismic	Pit 9 and Acid Pit	No
Buried Waste Robotics ^b	1991	Electromagnetic	Pit 9	No
Ebasco Environmental ^c	1992 to 1993	Magnetic and electromagnetic	Entire SDA	Yes
EG&G Idaho ^d	1992	Magnetic	Pit 9	Yes
S. M. Stoller Corporation ^e	1995	Magnetic, electromagnetic, and seismic	Pit 9	No
GeoSense ^f	1998	Magnetic and electromagnetic	Pit 9	Yes
Harding Lawson Associates ^g	1999	Magnetic, electromagnetic, and seismic	Pits 4, 6, and 10	Yes
Sage Earth Science ^g	1999	Magnetic and electromagnetic	Pits 2, 3, and 5; SVRs 1 through 12 and 14	Yes
U.S. Geological Survey ^h	2000	Very early time electromagnetic prototype	Pits 4 and 10	Yes
Sage Earth Science ⁱ	2001	Magnetic and electromagnetic	SVR 20	Yes
Sage Earth Science ^j	2003	Magnetic and electromagnetic	Pad A, SDA east, SDA southwest, Trench 3, Trench 47, Trench 57	Yes
Sage Earth Science ^j	2004	Magnetic and electromagnetic	Entire SDA except Pit 9 and active Low-Level Waste Disposal Facility	Yes

a. Hasbrouck (1989).

b. Griebenow (1992).

c. Ebasco Environmental (1993).

d. Roybal, Carpenter, and Josten (1992).

SDA = Subsurface Disposal Area

SVR = soil vault row

e. Stoller (1995).

f. Appendix A of Josten (2002).

g. Sage Earth Science (1999).

h. Abraham, Smith, and Wright (2003).

i. Carpenter (2001).

j. Josten (2005a).

Figures 3-28 and 3-29 are shaded relief maps of high-resolution magnetic and electromagnetic geophysical surveys compiled to show the entire SDA. Surveys covered all readily accessible parts of the SDA; therefore, the colored regions in Figures 3-28 and 3-29 correspond to the area inside the SDA perimeter dike. The two sizable areas that are not surveyed are Pad A (west of Pit 5 in the north-central portion of the SDA) and the Low-Level Waste Disposal Facility (in the eastern portion of the SDA). Boundaries for pits and trenches in the northern portion of the SDA are readily apparent because most waste was contained in metal drums. However, pit and trench boundaries are more difficult to define in southern portions of the SDA where the waste may have had a lower metal content (Josten and Thomas 2000) or because more of the waste may have been buried in nonmetallic containers or without packaging.

3.5.2 Identification of Areas for In Situ Characterization

Geophysical surveys were used with buried waste information (see Section 3.3) to identify locations for installing sealed probes used for in situ characterization of buried hazardous and radioactive waste (see Section 3.6). Geophysical surveys initially were used to identify areas where probes were installed during in situ characterization of Pit 9 (see Section 3.6.4). Results from probing Pit 9 were subsequently used to determine the location of the Operable Unit 7-10 Glovebox Excavator Method Project retrieval (see Section 3.1.5).

Similarly, geophysical surveys have been used with waste disposal information to identify areas for in situ characterization of several SDA disposal areas outside of Pit 9 (see Sections 3.6.5 to 3.6.9). This approach has proven useful to locate buried waste in areas thought to contain unrecorded waste disposals, as well as to characterize areas where disposal locations were well documented.

For example, Figure 3-30 shows results of a high-resolution magnetic geophysical survey conducted over SVR 12, which lies in the southeastern portion of the SDA. Soil Vault Row 12 is a series of vertical holes drilled into surficial soil. Radioactive waste was placed in vaults and then covered with clean overburden. Disposal records indicate that neutron-activated metal from INL Site reactor operations was included in waste buried in SVR 12. Activated metal often contains significant amounts of C-14 generated by transmutation of nitrogen in the metal.

Magnetic anomalies identified in Figure 3-30 corroborated the locations identified in disposal records for activated stainless steel components. Subsequently, these surveys were used to identify locations for probes to monitor release of radioactive contaminants into soil vapor immediately adjacent to the buried reactor components (see Section 3.6.9.1). High concentrations of C-14 in adjacent soil gas could be interpreted as an indication of ongoing corrosion of the activated metal components.

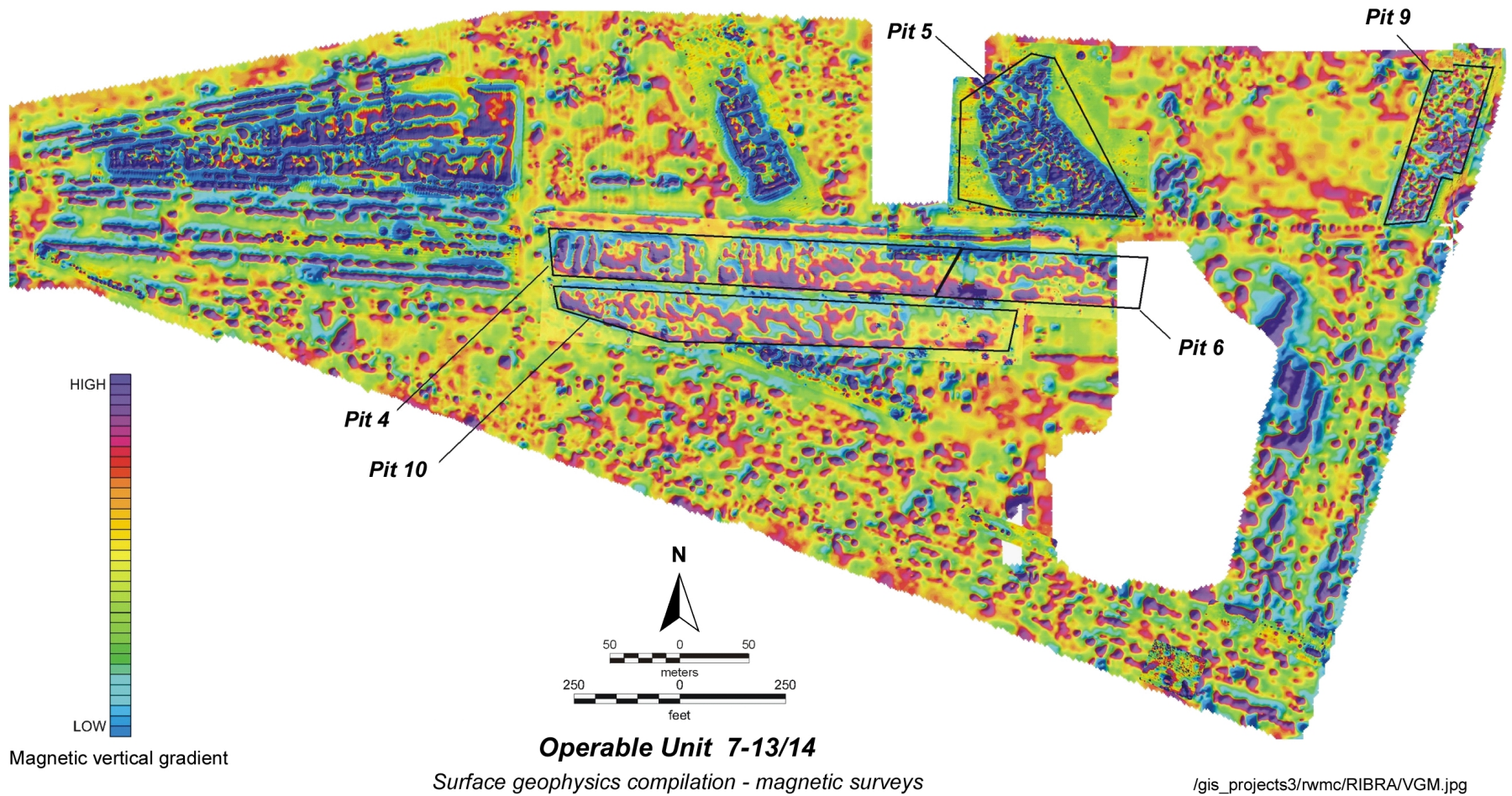


Figure 3-28. Magnetic geophysical survey of the Subsurface Disposal Area.